The EDITOR'S PAGE

Heating · Piping *and* Air Conditioning

THIS MONTH—

Because of an expansion in the manufacturing facilities of Eli Lilly and Company it became necessary in 1931 to provide for increased quantities of steam and electricity; it was decided to interchange power with the Indianapolis Power and

Light Company, which supplies Eli Lilly with high-pressure steam through an underground line a mile long.

William A. Hanley—in an article which is perhaps the most comprehensive ever written on this subject—describes the factors involved in reaching this decision and discusses in detail the provisions of the contract which governs the cooperation. His paper is this month's "lead."

According to newspaper reports, 90% of the neighborhood theaters in one large city are to close this summer, instead of the usual 5 to 10%, because of decreased receipts in summer and overhead expenses. Many movie houses have found the secret to successful summer operation in an air conditioning system; in this issue, a system which has served a small neighborhood house to the benefit of the management and the patrons is described.

"On the Job" is a department devoted to short, practical articles on the day-to-day problems that arise in connection with the installation, operation and maintenance of air conditioning, heating and piping systems. It's particularly interesting this month.

An ever-increasing list of substances and materials is being utilized in manufacturing processes and handled by industrial employes. Many of them are of such nature as to be dangerous if breathed repeatedly. Proper ventilation of industrial buildings is essential from this standpoint alone; often recovery is economically advantageous.

In this issue, John H. Ruckman writes on preventing air pollution in the plant, illustrating what can be done by means of actual examples. His paper includes a classification of objectionable materials often met with.

Low-cost protection for a fur-storage vault is provided in a Chicago department store by the introduction of carbon tetrachloride into the ventilating air. This arrange-

ment is said to protect the garments in storage from moths at a cost of about four cents each (each garment, not each moth) per year; the system is described by Milton K. Arenberg in this issue; his article is on page 338.

As a result of experience with some 600 buildings, John M. Robertson makes a real contribution to the engineer concerned with the design of a building to be heated intermittently in his article in this number. A heating plant may be of sufficient capacity to keep such a structure at a comfortable temperature once it is warmed up, but capacity is needed to raise the building materials to the proper temperature.

Mr. Robertson has made tests showing the rate at which typical types of construction absorb heat, and in his article shows his results graphically.

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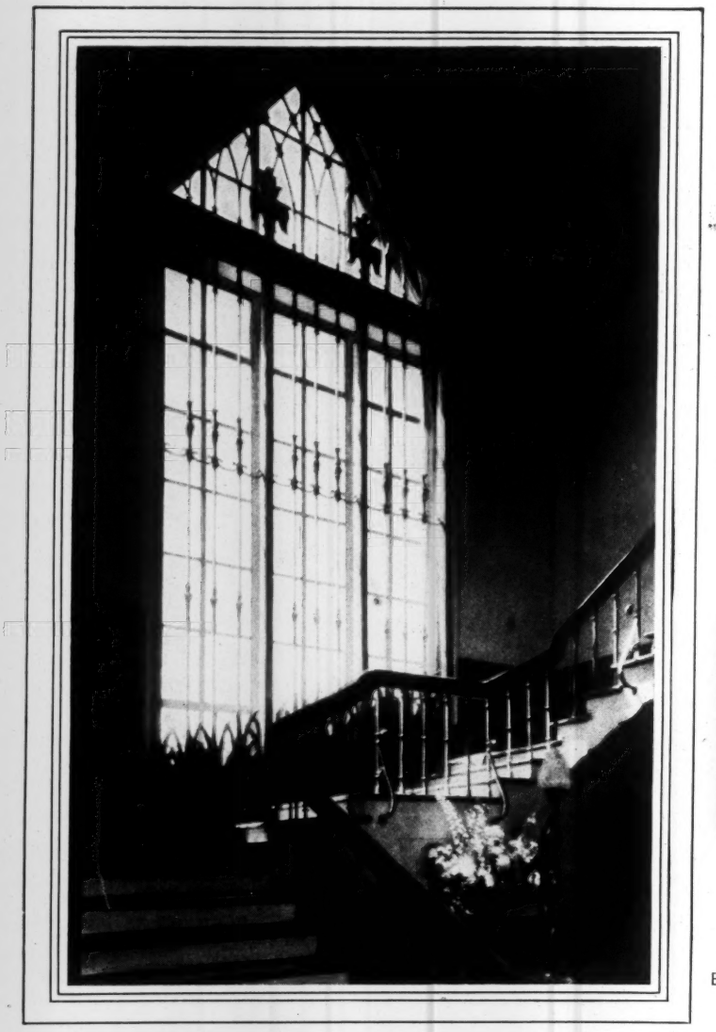
NEXT MONTH—

"Proper refrigeration is one of the essentials of good bread-making" according to many modern bakers; in the June issue, Arthur W. Archer writes on refrigeration piping in the bakery in an article of interest to engineers concerned with refrigeration piping for any process. . . . Heating and ventilating Chicago's new post office will be described by George W. Ott next month; because of its size and its erection over railroad tracks this building is particularly notable. . . . Many other articles on the problems of the air conditioning, heating, and piping engineer will be published in the June number. Don't miss it!

JOHNSON Heat and Humidity Control



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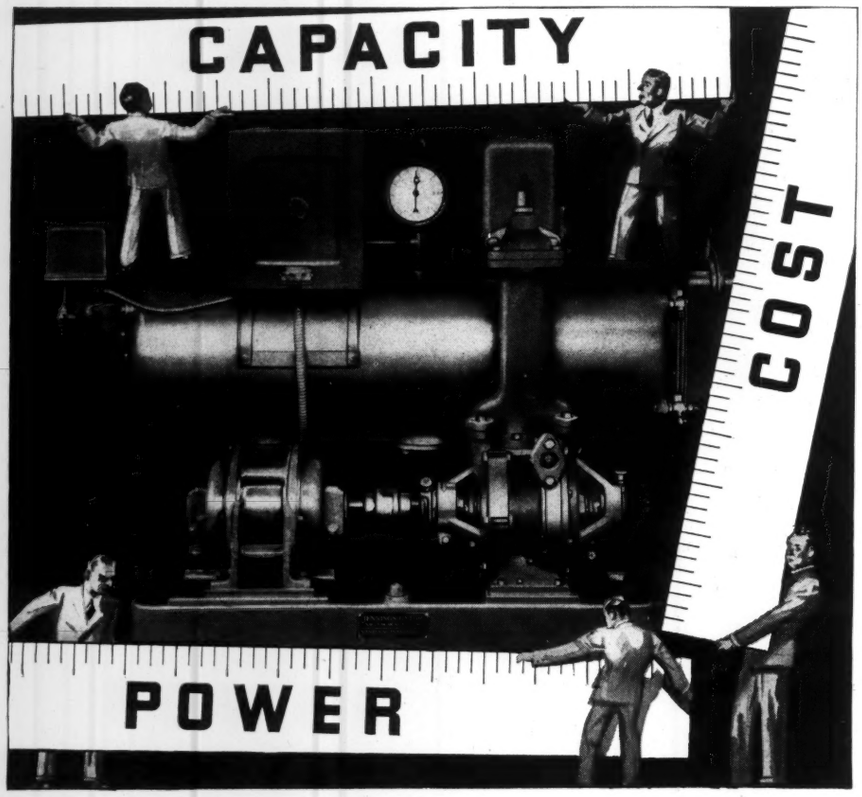

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Heating · Piping and Air Conditioning

Vol. IV | May, 1932 | No. 5

Plant and Utility Exchange Steam and Power—$70,000 Saving Estimated

By William A. Hanley*

Here is an article that every industrial plant engineer, consulting engineer and district heating engineer will want to read. It explains in detail the arrangement between Eli Lilly and Company and the Indianapolis Power and Light Company whereby steam for process and heating is supplied the company by the utility through a mile-long underground line; electric energy, generated by Eli Lilly, is fed into the utility's lines.

This article is perhaps the most comprehensive ever written on this new field; in it, Mr. Hanley (who is director of engineering for Eli Lilly and Company) quotes at length from the contract, an interesting engineering document.

The transmission of high-pressure steam and the interconnection of private and utility plants can in many instances be accomplished to the advantage of both. A careful study of several proposed arrangements was, of course, made as would be essential in any specific case.

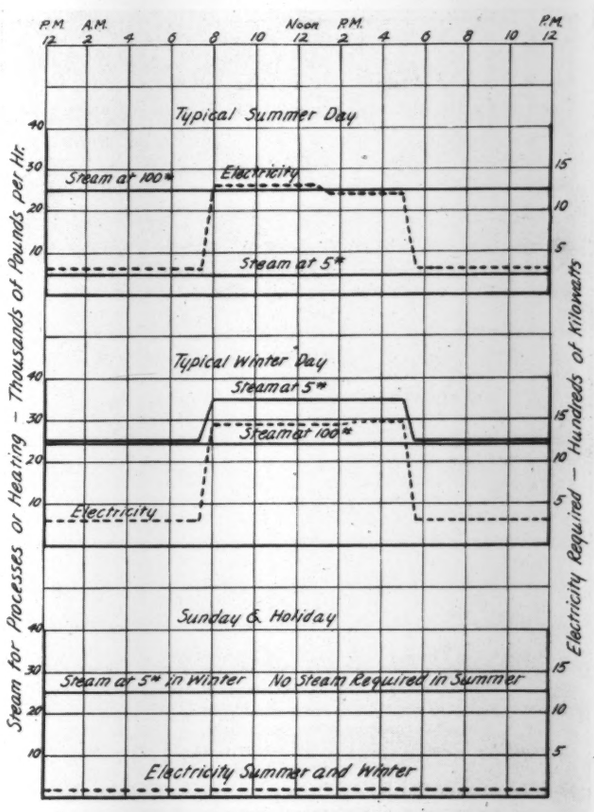

P.M. A.M. Noon P.M. P.M.
12 2 4 6 8 10 12 2 4 6 8 10 12
Typical Summer Day
Steam at 100#
Electricity
Steam at 5#
Typical Winter Day
Steam at 5#
Steam at 100#
Electricity
Sunday & Holiday
Steam at 5# in Winter
No Steam Required in Summer
Electricity Summer and Winter
Steam for Processes or Heating - Thousands of Pounds per Hr.
Electricity Required - Hundreds of Kilowatts

FIG. 1—PROCESS STEAM AND ELECTRIC REQUIREMENTS OF ELI LILLY PLANT

BECAUSE of an expansion of the manufacturing facilities at the Indianapolis laboratories of Eli Lilly and Company it became necessary in 1931 to provide for greater quantities of steam and electricity. Four schemes were considered as possible and the merits of each are herein discussed, and the reasons set out why an interchange of power was finally agreed upon with the Indianapolis Power and Light Company. The underground steam line which supplies high-pressure steam

*Director of Engineering, Eli Lilly and Company, Indianapolis, Ind.

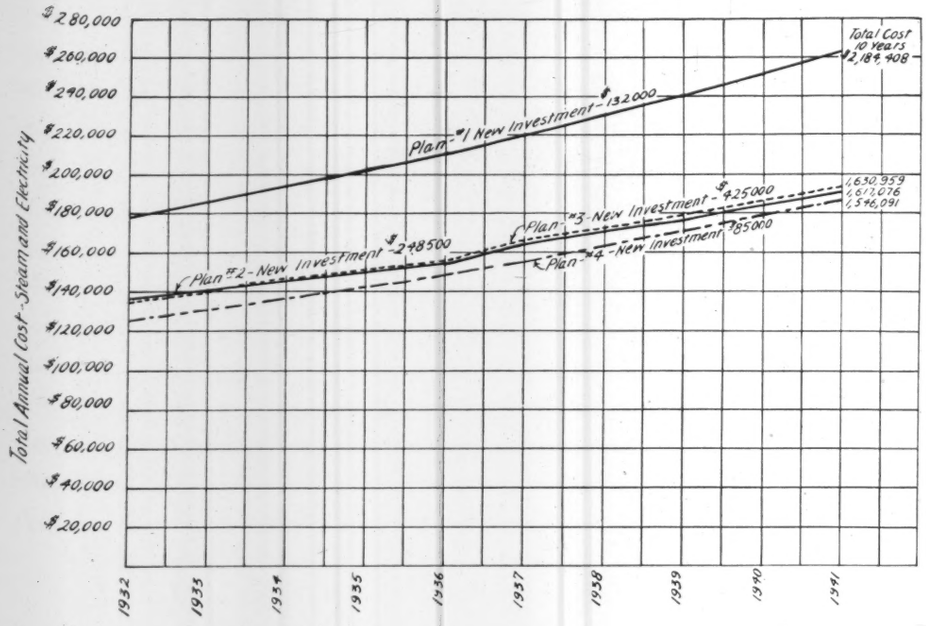


FIG. 2—INVESTMENT AND OPERATING COSTS FOR THE FOUR PLANS CONSIDERED IN THIS SPECIFIC CASE

Plan 1—New boilers in old power house; use old engines; buy all alternating current.

Plan 2—New boilers in old power house; new steam turbines; make all current.

Plan 3—New plant on new site; make all steam and electricity.

Plan 4—Buy all steam; new turbines in old power house; interchange current with power company.

to the Eli Lilly plant from the power company was described in an article by Robert L. Fitzgerald in the March, 1932, HEATING, PIPING AND AIR CONDITIONING.

Steam and Electrical Requirements

The problem consisted of providing steam with a maximum demand of 60,000 lb. per hr. in 1932 increasing to 100,000 lb. per hr. in 1942. Steam for normal manufacturing purposes at 100 lb. per sq. in. gage is slightly less than 50 per cent of the total requirement, while the remainder could be at as low as 5-lb. pressure for certain processes and heating. The electrical requirements were fixed at 1400-kw. demand for 1932, increasing to 2500-kw. demand by 1942. The total steam requirement was fixed for 1932 at about 350,000,000 lb., and the electrical requirement at slightly under 5,000,000 kw-hr.

The incidence of steam demand to electric demand on the average summer and winter working days is shown in Fig. 1.

Four Different Plans Studied

Plan 1 contemplated the installation in the old power house of two new boilers, each of 75,000 lb. per hr. capacity, to supply all steam requirements at 150-lb. pressure and to produce electric current with corliss engine-driven generators operated for twenty-five years and capable of generating about 15 per cent of the electric requirements, the remaining 85 per cent of electric current to be purchased at approximately 1.35c per kw-hr. For the first year of such plan the operating cost was estimated at nearly $43,000 more per year than *Plans 3* or *4*. This difference in annual operating cost would increase each year and in thirteen years total $800,000. The increased cost arose from the fact that under *Plans 3* and *4* the steam would be generated at 350 lb., would make all the electricity and then be used for process or heating; while in *Plan 1* the steam generated at 150 lb. would make only 15 per cent of the electricity needed. *Plan 1* would be dependable, capable of continuation for twenty years or more, but not economical.

Plan 2 contemplated installing in the old power house two boilers to operate at 350 lb. with superheaters to give a steam temperature of 700 F, and the replacement of the engine-driven generators with two steam turbines with a total capacity of 2500 kw. Because of location, condensing operation was impossible. The plan was very difficult of execution due to limited space and the necessity of continued operation of the factory during changes in the power plant. At best the anticipated electrical demands would outgrow electrical capacity in thirteen years with no possibility of expansion. The annual operating cost at once exceeded the cost under *Plan 4*, and at the end of three years exceeded annual costs of *Plan 3*. The plan was not flexible to get the most economical results should the ratio of electric demand to process steam and heating steam load be changed in future years.

Plan 3 contemplated a new power house with railroad facilities, two 75,000 lb. per hr., 350 lb. per sq. in., 200-F superheat boilers, one 2,000-kw. condensing turbine of the bleeder type, and one 500-kw. non-condensing turbine exhausting at 100 lb. pressure. In four years a third boiler would be installed. The plant could be extended, as warranted, to quadruple present demands. This plan provided an efficient power plant to cost $425,000, and would have been followed had not *Plan 4* been developed.

The Plan Which Was Adopted

Plan 4 (which was adopted and is now being put in operation) consists of purchasing all steam from the Kentucky avenue station of the Indianapolis Power and Light Company through a 6,000-ft. pipe line built by the power company for this particular purpose, the delivery pressure of steam to be at 175 lb. and 100 F superheat guaranteed. In the existing engine room the engines have been replaced with one 2,000-kw. condensing turbine built for operating at 350-lb. pressure and 200 F superheat, and one 500-kw. non-condensing turbine built for the same pressure and superheat. The two turbines have certain stages removed so

that economical operation can be secured from the 175-lb., 100-F superheat steam.

The present operation provides for exhausting the 2,000-kw. turbine at 5 lb. pressure, and the 500-kw. turbine at 100 lb. pressure. The turbines will operate only if and when steam is needed for process or heating, and will act simply as reducing valves. The current generated from these turbines feeds through meters directly into the lines of the power company; the electrical demands of the Lilly Company are satisfied from the lines of the power company. The power company must take at any and all times current to the capacity of the Lilly generators as the steam requirements of the latter generate. The steam is to be paid for monthly and the difference in electric current supplied or used is to be paid for annually. The allowance to the Lilly company is to be ¼c per kw-hr. for current supplied in any year over the amount used; the cost to the Lilly company is to be 1.35c per kw-hr. for current used in excess of the amount generated. It is contemplated the Lilly company will generate about 6,000,000 kw-hr. annually and use about 5,000,000 kw-hr.

The flexibility of the plan to the Lilly company and the heat balance which can be obtained is at once apparent. By throwing certain switches the Lilly company can run on its own turbines should electrical troubles develop outside the plant. The cost of the steam and the reliability of the pipe line and the boilers connected to it became the controlling factors. These factors were covered by an unconditional guarantee of continuous steam service by the power company, which gives the Lilly company the privilege of cancelling the steam contract if its operations were frequently interrupted.

The power company expended about $150,000 to build the pipe line. A price for steam was agreed upon, and the Lilly company guaranteed to purchase not less than $50,000 worth of steam in any year for a period of ten years.

Fig. 2 shows the investment and operating costs of the four plans considered by the Lilly company for producing its steam and electric power.

Reliability of Electric Supply

The reliability of the electric supply is assured as the Lilly company has not only its own plant but all the inter-connected plants of the power company. Should the steam line of the power company fail, the Lilly company has standing a steam plant, old but efficient, capable of producing 65,000 lb. per hr. of steam at 130-lb. pressure, which can be put in operation in three hours and which will not be dismantled for at least two years. Should it become necessary to cancel the contract for steam, the turbines recently purchased can be moved and *Plan 3* be carried out in less than twelve months.

The steam piping plan for turbines as they are now being installed is shown in Fig. 3.

Essential Features of the Contract

The essential features of the contract for steam and interchange of electricity and the rates are as follows:

1. Term of contract—ten years from date steam is first used.
2. Current to be interchanged—4100 volts, 3-phase, 60-cycle.
3. Power factor guaranteed by Lilly company to power company; 85 per cent when both turbines are operating, and 70 per cent when the 500-kw. turbine alone is operating.
4. Electrical loading of Lilly turbines entirely in the hands of Lilly engineers.
5. Settlements for electric energy to be made annually, the Lilly company receiving ¼c per kw-hr. for all current furnished by it in excess of amount used, and paying 1.35c per kw-hr. for all current used in excess of amount generated.
6. Interruptions of delivery of steam.

"(a) If, by reason of any avoidable cause on the part of the power company (meaning thereby any cause resulting from its own fault or negligence or which might have been reasonably anticipated and removed by it) the delivery of steam to the customer shall be frequently interrupted so as to materially embarrass the customer's operation or to burden it with substantial expense, the customer shall have the option to cancel and terminate this contract by giving reasonable notice to the power company of its intention so to do, provided that such cancellation shall not affect any right or remedy, legal or equitable, that may accrue to the customer; nor shall the failure to exercise such option affect such right or remedy.

"(b) If, by reason of any unavoidable cause (meaning thereby any cause over which the power company has or shall have no control) the delivery of steam to the customer shall be frequently interrupted so as to materially embarrass the customer's operation or

THE PLANT OF ELI LILLY AND COMPANY AT INDIANAPOLIS, WHICH BUYS STEAM

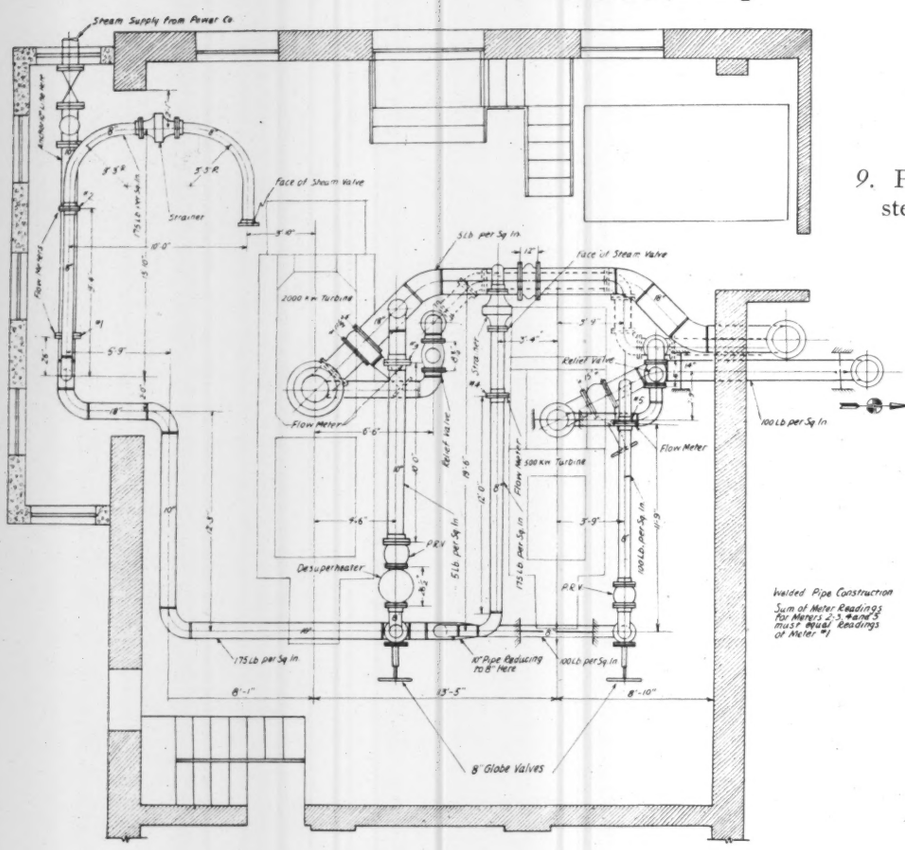


FIG. 3—PIPING PLAN FOR TURBINES

to burden it with substantial expense, the customer shall have the option to cancel and terminate this contract by giving reasonable notice to the power company of its intention so to do. The power company shall not, in any event, be liable to the customer for any interruption of the delivery of steam to the customer due to or caused by any unavoidable cause. The cancellation and termination of this contract by the customer as herein provided, shall not affect the obligation of either party to pay for steam and/or electric energy theretofore delivered to the other and not paid for.

"No failure of the customer to exercise the right of cancellation under either sub-paragraphs (a) or (b) shall be deemed a waiver of its right to cancel and terminate this contract on account of any continuing or subsequently happening cause of cancellation."

7. Transformers or other such equipment rented by the Lilly company from the power company shall be maintained by the power company, and the annual rental shall be 14.85 per cent of the cost of such equipment, payable monthly.

8. Should change in steam or electric rates be made mandatory by order of Court or Public Service Commission. "Both parties agree that if for any reason the rate, for either steam or electric energy, as established by this contract, is changed, except as provided in the coal clause, so as to affect adversely either party, the party thus affected is privileged to cancel and terminate this contract by giving a reasonable written notice to other party."

9. Penalty for sub-standard quality of steam.

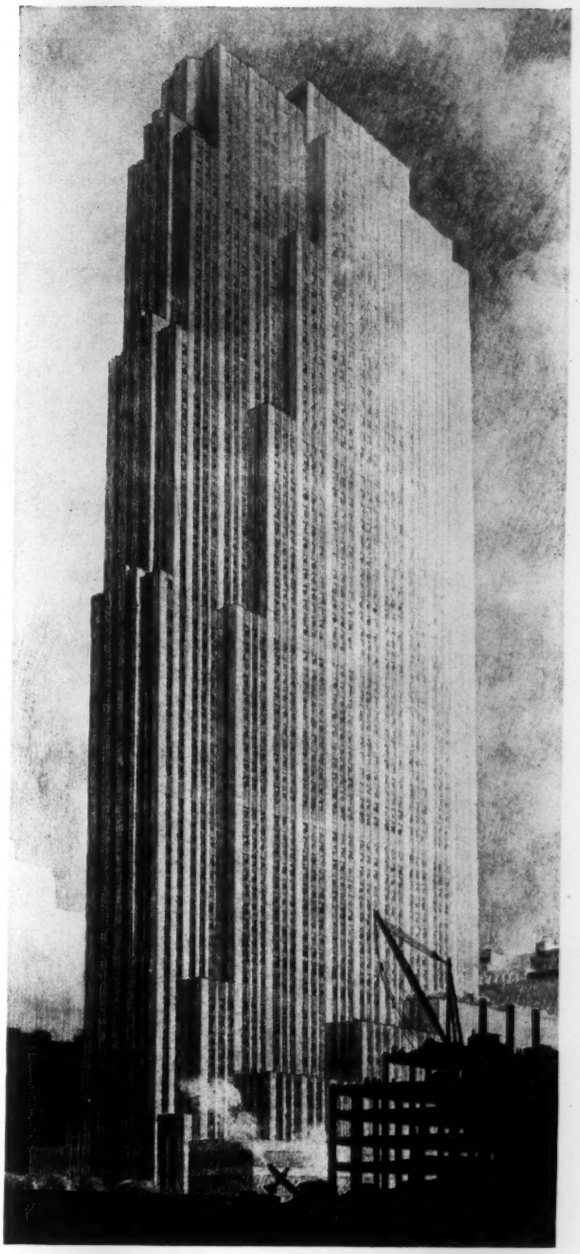
"When the steam is flowing at any rate between sixty-five thousand pounds per hour and one hundred thousand (100,000) pounds per hour, and the steam pressure is approximately one hundred and seventy-five (175) pounds gauge pressure and the total temperature of the steam falls below four hundred and sixty-two (462) degrees Fahrenheit, two per cent (2%) shall be deducted from the net amount of the bill for each ten (10) degrees that the actual superheat is below four hundred and sixty-two (462) degrees Fahrenheit, for the total amount of steam delivered under these conditions at the sub-normal temperature.

"When the steam is flowing at any rate less than one hundred thousand (100,000) pounds per hour and the steam pressure falls below one hundred and sixty-five (165) pounds gauge pressure, three per cent (3%) shall be deducted from the net amount of the bill for each ten (10) pounds that the gauge pressure is below one hundred and sixty-five (165) pounds, for the total amount of steam delivered at such sub-normal pressure."

In final comparison under *Plan 4* the Lilly company is spending $85,000 and the power company $150,000. The expenditure under *Plan 3* would have been $425,000 by the Lilly company and nothing by the power company; there is thus $190,000 saved in investment. It is true, of course, that some of the investment in the power company's station will be used, but this investment has a return made on it through the steam sold. It is anticipated that the power company will make about $15,000 net per year from the investment in the $150,000 steam line and that the Lilly company will save about $70,000 in ten years over the cost of operating a new plant. The entire scheme was worked out by both companies frankly and openly discussing all details of cost and operating and neither jockeying for any particular advantage. The transmission of high-pressure steam and the interconnection of utility and private plants can *in many instances* be accomplished to the advantage of both the utility and the industrial concern and will certainly be an important step in power developments of the future.

Note: In next month's issue, the terms of the contract relating to provisions for any change from coal fuel, the disposal of the old boilers in the Lilly plant, meters, coal cost arbitration, payments and billing will be explained.

By . . . . . **W. Walter Timmis***



ARCHITECT'S DRAWING OF THE 70-STORY OFFICE BUILDING

Zone Control of Radio City Heating System

Rockefeller Center — or Radio City, as it is more widely known—is a $250,000,000 building project which will transform the three blocks from 5th to 6th Avenues between 48th and 51st Streets in New York City into the "world's greatest office, shop, and amusement center." This article describes the zoning of the heating system of the 70-story central tower building, now under construction.

Owner: Metropolitan Square Corporation; Builders and Managers: Todd, Robertson and Todd Engineering Corporation; Architects: Reinhard & Hofmeister—Corbett, Harrison & MacMurray—Hood & Fouilhoux; Consulting engineer: Clyde R. Place; Heating Contractor: Baker, Smith & Co., Inc.

HEAT control of the central tower building of Radio City, the Rockefeller development in New York City, presents an interesting problem because of the diversity of requirements in the various sections of the building, and because of the enormous size and great height of the building. It is 70 stories high, with 2,500,000 sq. ft. of floor space.

In spite of the complexity of the problem, the mechanical engineer, Clyde R. Place, has designed the distributing system with the utmost simplicity. The distributing system has been divided into 12 zones. The factors considered in arriving at this zoning were exposure, stack effect of building, and type and hours of occupancy.

Fig. *2* shows the arrangement of the zones. The building has been split vertically so that Zones *4, 6, 8,* and *10* take in the south half, while Zones *3, 7, 9* and *11* take in the north half. This zoning is for exposure. The building has also been split horizontally at the 4th, 11th, 32nd, 45th and 64th floors, to take care of the stack effect of the building. The neutral point of the building, so far as stack effect is concerned, is at the 32nd floor. Below this floor there will be a negative pressure and above it a positive pressure.

The vertical zoning makes it possible to supply heat at

*Manager, New York office, C. A. Dunham Co.

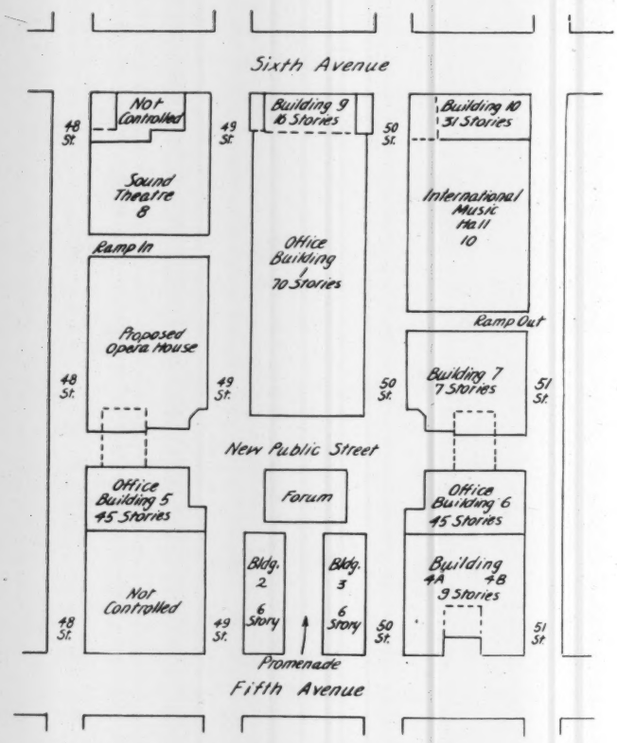


FIG. 1—GENERAL LAY-OUT OF ROCKEFELLER CENTER

a higher rate to the zones on the north side than to those on the south. The horizontal zoning makes it possible to supply heat to the zones above the 32nd floor at a rate lower than to the zones below.

The remaining zones represent special treatment for type and hours of occupancy. Zone *1*, comprising the ground and 2nd floors, will be devoted mainly to banking quarters and shops. Here zoning for exposure is not important because of the close shelter provided by neighboring buildings. Building *9*, comprising Zone *5*, will be given over to occupancy of special type differing from the other portions of the building; here also the shelter of neighboring buildings makes zoning for exposure not essential. Zone *2* comprises the studio of the National Broadcasting Company; it will be completely air conditioned, the direct radiation being used only to take care of transmission losses. Each of the radiators in this zone will be controlled by an individual pneumatically-operated thermostat.

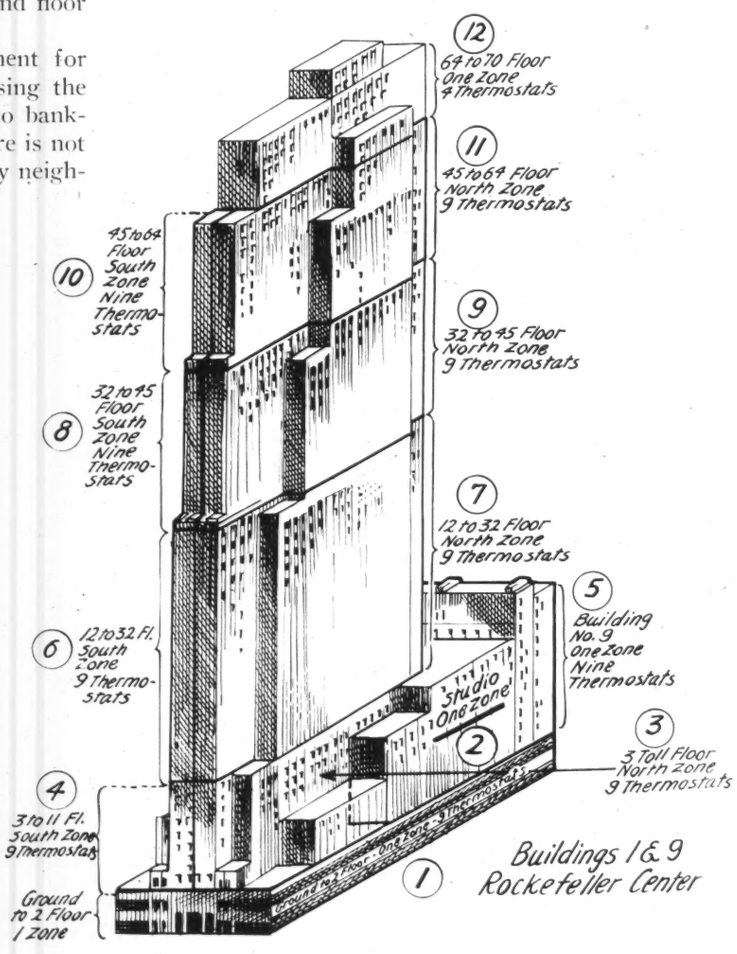
All the ventilation heater stacks will be supplied separately. The returns will also come back separately to a separate vacuum pump. The same applies to the air conditioning in the studio.

Steam at 50 lb. will be carried to the supply point of each zone and there reduced to 2 lb. Temperature control in each zone will be attained by an additional stage of reduction, which will automatically reduce the pressure, and consequently the temperature of the steam, to whatever point and quantity is required to balance the heat loss from the zone while maintaining an average temperature of 70 F in the zone.

Fig. 3 illustrates how this is accomplished. Nine thermostats are located in each zone. These thermostats operate on the potentiometer principle. A slight variation in temperature causes a change in the amount of current transmitted through the thermostat to the electric motor on the control valve for the zone. The change in amount of current is proportional to the variation in temperature, above or below the normal setting of the thermostat. This change in the amount of current causes the electric motor to move, the amount of movement being proportionate to the change in current, and hence to the variation in temperature. The movement will be either clockwise or counter-clockwise, depending on whether the temperature variation is above or below normal.

As all nine thermostats are connected in series-parallel, it is the average effect of all nine which is transmitted

FIG. 2—ARRANGEMENT OF THE HEATING SYSTEM ZONES IN BUILDINGS 1 AND 9


12
64 to 70 Floor One Zone 9 Thermostats
11
45 to 64 Floor North Zone 9 Thermostats
10
45 to 64 Floor South Zone Nine Thermostats
9
32 to 45 Floor North Zone 9 Thermostats
8
32 to 45 Floor South Zone Nine Thermostats
7
12 to 32 Floor North Zone 9 Thermostats
6
12 to 32 Fl. South Zone 9 Thermostats
5
Building No. 9 One Zone Nine Thermostats
Studio One Zone
2
3
3 to 11 Floor North Zone 9 Thermostats
4
3 to 11 Fl. South Zone 9 Thermostats
Ground to 2 Floor One Zone 9 Thermostats
Ground to 2 Floor 1 Zone
1
Buildings 1 & 9 Rockefeller Center

to the electric motor, which of course controls the opening of the control valve. Hence, steam is constantly measured off in accordance with the average requirements of the zone. It will be noted that the thermostats average both horizontally and vertically in each zone.

Having thus provided for automatically measuring off steam at a rate which will replace the heat being lost from the zone, the next problem was to insure the proper circulation of this steam to all radiators in the zone. This is done by rarifying or expanding the steam by means of a vacuum pump to facilitate its control, insuring a differential in pressure between the steam and return systems which is governed by a special electrical controller operating in conjunction with the vacuum pump, and by the installation of orifices. Steam pressure on the supply side will vary from 2 lb. to 23 in. vacuum, while the pressure on the return side will follow the pressure on the supply side, being kept at a point approximately 1 lb. (absolute) lower than the pressure on the supply side.

Special orifices are installed at the inlet to each radiator, the orifices being sized with regard to radiator capacities and pressure drop; they are for the purpose of securing an equitable distribution of steam, compensating for unavoidable variations in figuring radiation requirements, etc.

An individual occupying a room in which he is for all practical purposes the sole occupant to be considered, can secure a variation in the temperature of his room above or below the normal to suit his preferences. This is accomplished by varying the size of the orifice in the radiator. Of course, such a variation can be secured in any room, but in a room subject to the preferences of a number of people, the temperature must be maintained at a point which is generally agreed upon as producing average optimum comfort, 70 F.

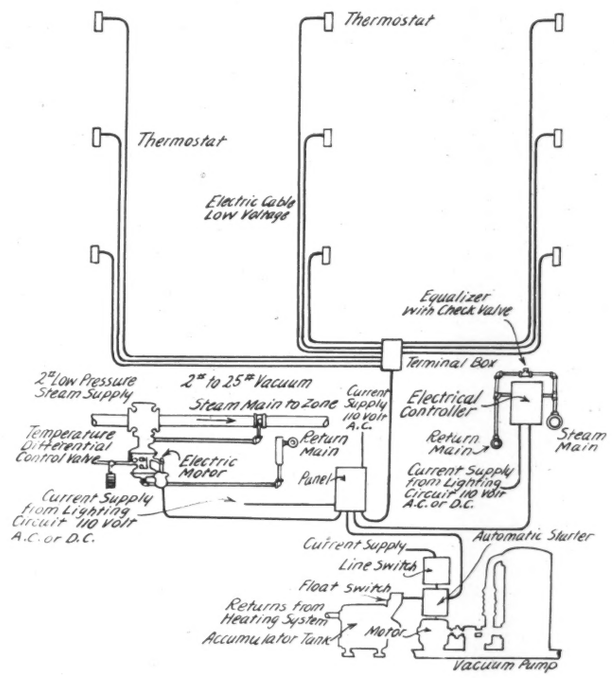


Fig. 3—Schematic Diagram Showing Method of Controlling the Steam for Heating

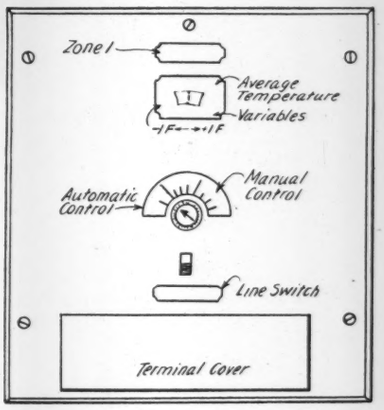
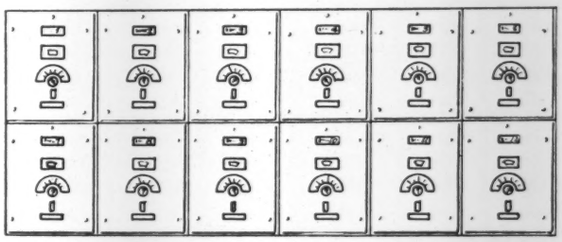


Fig. 4—(Below) Diagram Showing the Arrangement of the Zone Control Panels Left—View of Control Panel; Note the Finish



In the superintendent's or engineer's office there will be located a control panel for each zone, as illustrated in Fig. 4. The dial at the top will indicate to the operator the temperature condition in each zone. With the small control knob in the center he can place any zone under automatic control, or he can regulate the control valve for each zone manually. He can close steam off entirely on any or all zones by means of this same knob. The vacuum pumps serving the zone systems also can be started and stopped from the control panels.

The south zones, *4, 6, 8* and *10,* are connected to one main return pipe which goes to a vacuum pump. The north zones, *3, 7, 9* and *11* and the top zone, *12,* are connected to one main return which goes to another vacuum pump. An additional pump is placed between these two for standby service. These are located in the basement of Building *1.* The returns from zones *1* and *5* go to a vacuum pump located in the basement of Building *9.*

Steam will be supplied at atmospheric pressure or above to the radiators in Zone *2* (the broadcasting studio), these radiators being under individual thermostatic control. The returns go to a separate vacuum pump located in the basement of Building *9.*

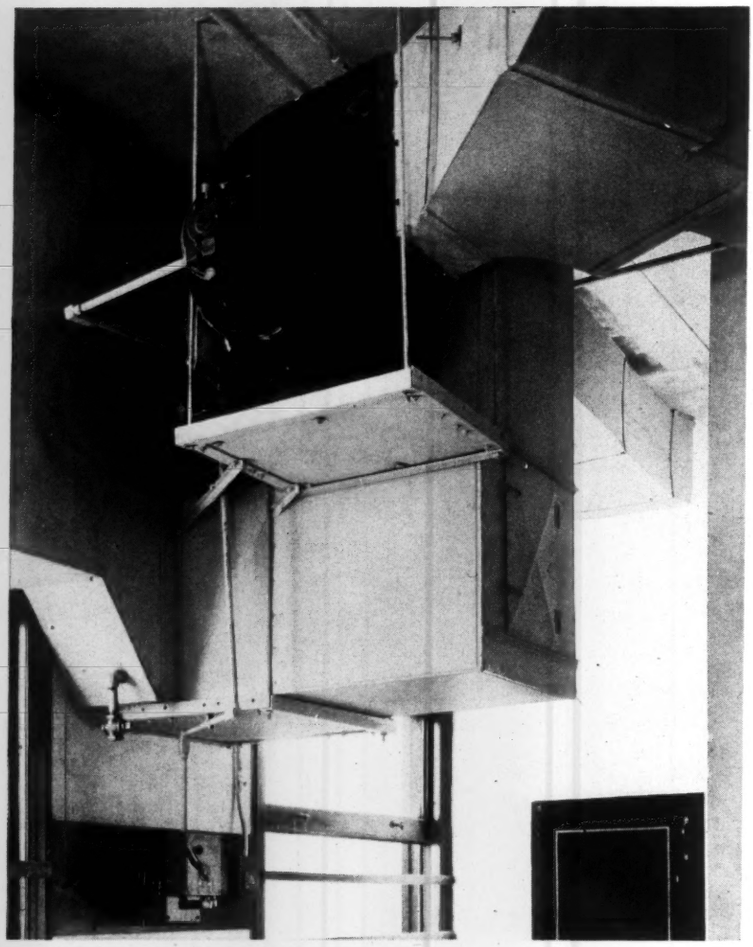


FIG. 1—THE FRESH AIR SUPPLY, SHOWING THE BLOWER, FILTER AND THE RECIRCULATING DUCT

By Milton K. Arenberg*

LOW-COST PROTECTION OF FUR STORAGE VAULT

MOTHS and their eggs have long been known as the arch-enemies of wearing apparel, particularly that which is not clean. However, a moth is also particular about the kind of material upon which it displays its talents. It has no desires for dyed furs, preferring instead to inhabit and consume natural furs, particularly such expensive ones as mink, sable, beaver, natural karakul, raccoon, muskrat and others.

Carbon Tetrachloride Used as Fumigant

The Boston Store, one of Chicago's larger loop department stores, decided to expand its fur department by installing a storage vault and the necessary repairing, glazing and cleaning departments. Naturally, a low-cost positive means of moth destruction and prevention was sought. After careful consideration the introduction of filtered outside air, positive exhaust and the use of carbon tetrachloride (CCl_4) as a fumigant was decided upon.

The Storage Vault

The vault is of fire- and burglar-proof construction 42 ft. wide, 70 ft. long, and 13 ft. high. It has a capacity of 10,000 coats hung four inches apart on double-deck racks constructed of 1-in. pipe. Adjoining its exterior is a fumigating room 4 ft. wide, 16 ft. long, and 13 ft. high, which holds 60 garments.

Handling the Furs

All garments when received are carefully examined for larvae and the fur is beaten by hand, which will raise any hair that is loose (this being the signal that moths are or have been at work). All natural furs are sub-

*Chicago district manager, Ilg Electric Ventilating Co., Chicago, Ill.

The ventilating, filtering and fumigating system described here protects furs in storage for about four cents per garment per year. » »

jected to an additional combing with a wire brush and a double inspection.

The furs are then placed in the fumigating room for eight hours during which time five quarts of carbon tetrachloride are evaporated into the air and allowed to remain there, the air supply and exhaust being shut off. The fans are then started and in twenty minutes the operator can enter and remove the garments to the vaults.

The Ventilating Equipment

There is a self-cleaning automatic filter at the fresh air intake and a blower direct connected to a 1-hp., 220-volt, direct-current motor at 685 r.p.m. supplies 3,500 c.f.m. to the vault. The blower and air filter are mounted on a platform suspended from the ceiling in the inspection room as shown in Fig. 1.

The supply blower is connected to the exhaust duct so that, by means of dampers, the air in the vault can be recirculated while fumigating. This provides a thorough distribution of the chemical throughout the vault.

The supply ducts are at the floor at each side of the room. All ducts have tight, soldered seams and joints; 8 in. x 8 in. openings with slide dampers, placed approximately 8 ft. apart, each introduce 225 c.f.m.

Introducing the Fumigant

Two 10-gal. drums of carbon tetrachloride are mounted on the wall in the inspection room, each having a 1-in. pipe extending into the vault and running on top of the supply duct. A ¼-in. connection is taken off at every air supply opening; this connection has a pet cock opened just enough to admit the chemical drop by drop into the air stream, which immediately vaporizes it.

A blower of the same capacity as the supply blower exhausts the air from the vault through a duct at the ceiling in the center of the room.

Air at outdoor temperature is supplied and exhausted for eight hours each day, except once every six weeks when the vault is fumigated. This process starts on a Saturday evening about two hours before closing time. The chemical is introduced during these two hours and then shut off and allowed to remain in the vault until Monday morning when a fresh supply is again introduced for two hours. The ventilating system only is then run for an hour and a half at which time the vault is clear of all chemical and the operator can enter without a mask.

Operating Costs and Results

One thousand four hundred lb. of carbon tetrachloride are consumed per year at a cost of approximately $100.00 or about 2c per garment per year, the average number in storage being about 5,000. The electrical power cost is $94.00 per year making a total operating cost of slightly less than 4c per garment.

The writer has inspected a mink coat that has been in this vault continuously for three years. There are no signs of moths, it still retains a high glaze and the fur is soft and smooth. The skin has not shrunk and is very pliable, which—it is said—is a true test of proper fur storage.

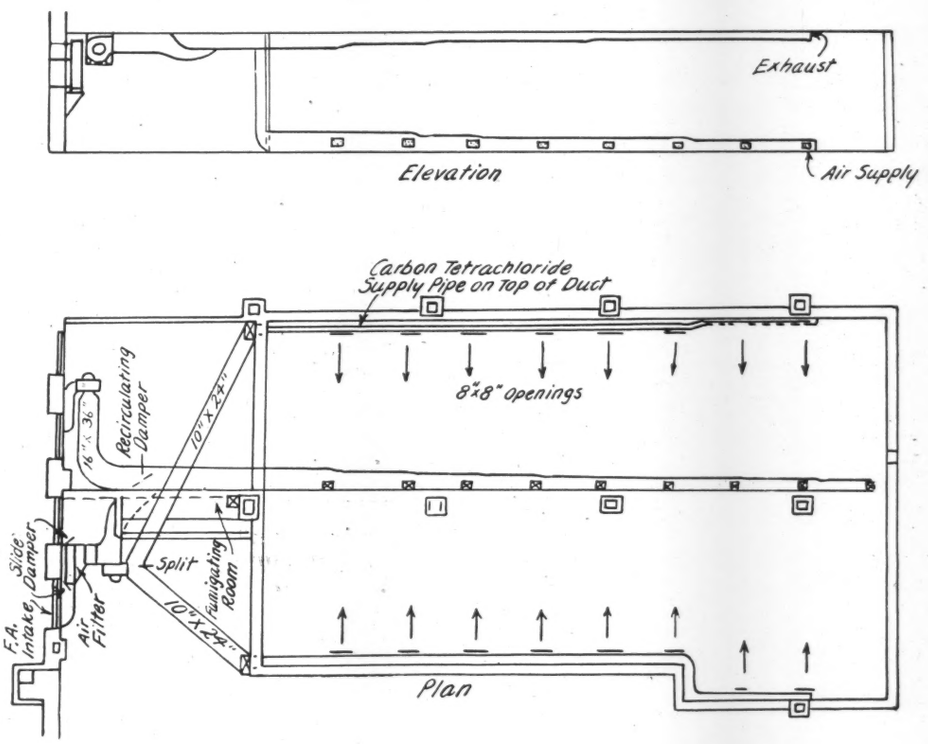


FIG. 2—PLAN AND ELEVATION OF THE VENTILATING SYSTEM WHICH PROTECTS FURS IN THE STORAGE DEPARTMENT OF THE BOSTON STORE, CHICAGO

Heating-Up Load for Buildings Heated Intermittently

Tests Show Amount of Heat Required to Warm Building Materials • •

From the experiments and calculations described in this article and from a wide experience with intermittent heating, the author believes that the usual recommendations for the percentage to be added to total heat loss to care for heating up the materials in buildings heated intermittently are far inadequate, that the heating-up load cannot be ascertained with any degree of accuracy by allowing a percentage of the normal heat loss load, and that when sufficient capacity is provided to care for the heating-up load, there must be means for quick and positive temperature control.

A method of making tests to determine the rate at which various building materials absorb heat is described, and curves are presented showing the results of some of these tests.

Little attention has been given this important subject in text and reference books or in the technical press.

By John M. Robertson*

WHEN a building is heated at infrequent intervals, all of the materials inside the building—the floors, walls, seats and furniture—cool between periods that heat is supplied to a temperature dependent upon the length of time there is no heat and upon the outside temperature. When it is again heated, these materials must be heated with the air, and during the heating-up period, absorb heat from the air.

To care for this additional load, the code of minimum requirements of the *American Society of Heating and Ventilating Engineers* states that 10 per cent should be added to the total heat loss through exposed surfaces for daily intermittent heating, and 25 per cent for heating at intervals of several days. No other authority that has come to the attention of the writer specifies a greater amount.

During experience with some 600 buildings used intermittently, under a policy of adding approximately 100 per cent to the calculated normal heat loss through exposed surfaces to care for the heating-up of interior materials, widely varying results have been obtained. After computing the total heat requirements for two buildings in the same locality, of equal size but with somewhat different interior construction, and with heat losses almost the same, and after equipping the two buildings with heating plants of the same capacity, one building will heat quickly and readily, and the other very slowly. The increasing use of fireproof and semi-fireproof construction has made this much more pronounced and some experiments have been undertaken to determine just why the heating-up load is so much greater in one building than in another. While they are not far enough advanced to offer complete data for various building materials, sufficient results have been obtained to reveal information of a surprising nature.

Churches Present Severe Problems

In the group of buildings heated intermittently, churches present the most severe problems since large portions of the buildings are used only 2 to 4 hours a week. Unused portions of churches should be maintained at a temperature not lower than 50 F for the

*E. K. Campbell Heating Co., Kansas City, Mo.

proper care of organs and furniture, but in many churches little, if any, heat is supplied to rooms not in use. Frequently the temperature of the air and all materials and furniture drops to 35 or 40 F. Seldom is more than 10 per cent of the building heated continuously for week-day activities.

HOPE LUTHERAN CHURCH, ST. LOUIS, MO.

Determine Rate at Which Building Materials Absorb Heat

It is a simple matter to calculate the total heat required to raise the temperature of a known mass of building materials from 35, 40 or 50 F to 70 F, but to obtain the hourly load on the heating plant it is necessary to know the rate at which the materials absorb heat. To determine this rate a number of samples of common wall and floor construction about 18 inches square were prepared, with thermometers buried to different depths in the materials. The edges of the samples that in actual construction would be joined to a wall or floor, were insulated with 1 in. of loose hair felt to insure the heating of the materials through the faces that would normally be exposed to the air of the rooms.

The samples were cooled throughout to a uniform temperature, then placed in a room in which the temperature of the air was maintained near 70 F; readings of the thermometers were made each 15 minutes.

Curves Show Rates for Materials

The curves in Fig. 1 show the rate at which some materials absorbed heat under these conditions. In the range of temperatures between 50 and 70 F the conditions under which the samples were tested are quite similar to those existing in a building when the inside materials are being heated through the same range Most buildings of the type that are heated intermittently are equipped with circulating devices that permit the heating of the air to 70 F in a very short time, regardless of the time required for the materials in the building to absorb heat. Observations and tests in a number of buildings so equipped indicate that by the time the temperature of the materials in a building has reached an average of 50 F after starting with a temperature approximately 40 to 45 F, any heating plant of adequate capacity will have heated the air in the building to 70 F.

Therefore, from 50 to 70 F, the rate of heating indicated by the curves may be assumed to apply to materials in a building being heated under average conditions, with sufficient accuracy for practical purposes. And in extreme weather, at the same time the heating plant is supplying heat to warm the materials from 50 to 70 F it is supplying the full normal heat loss through exposed surfaces, since the inside air is at a temperature near 70 F.

4 F Per Hour Average Temperature Rise Assumed

The curves indicate that in the range between 50 and 70 F all materials tested absorbed heat at a rate to produce an average temperature rise of 3 to 5 F per hr.

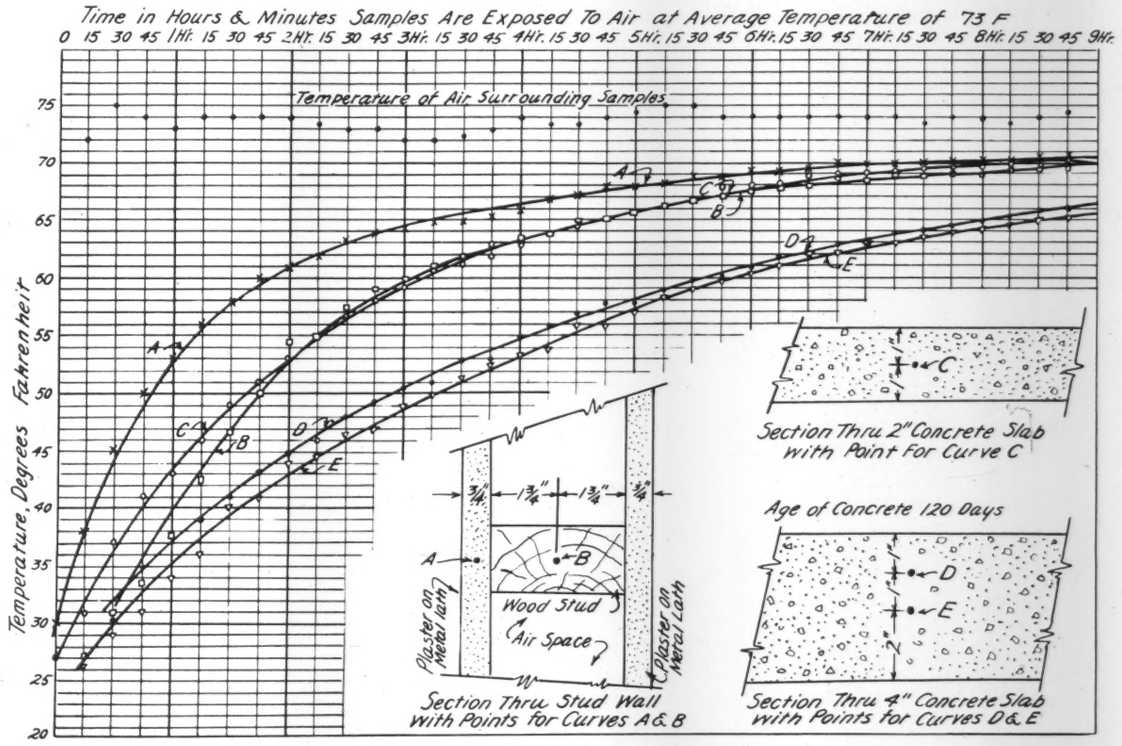

Time in Hours & Minutes Samples Are Exposed To Air at Average Temperature of 73 F
0 15 30 45 1Hr. 15 30 45 2Hr. 15 30 45 3Hr. 15 30 45 4Hr. 15 30 45 5Hr. 15 30 45 6Hr. 15 30 45 7Hr. 15 30 45 8Hr. 15 30 45 9Hr.
Temperature of Air Surrounding Samples
Temperature, Degrees Fahrenheit
75
70
65
60
55
50
45
40
35
30
25
20
A
B
C
D
E
Section Thru 2" Concrete Slab with Point For Curve C
Age of Concrete 120 Days
Section Thru 4" Concrete Slab with Points for Curves D & E
3/4"
1 3/4"
1 3/4"
3/4"
Plaster on Metal Lath
Wood Stud
Air Space
Plaster on Metal Lath
Section Thru Stud Wall with Points for Curves A & B

FIG. 1—CURVES SHOWING RATE AT WHICH SOME BUILDING MATERIALS ABSORB HEAT. THE TESTS ARE DESCRIBED IN THIS ARTICLE

Item	First Evangelical Church Indianapolis, Ind. Wood Floor Construction		Hope Lutheran Church St. Louis, Mo. Thin Concrete Floor Constr.		Scruggs M.E. Church St. Louis Mo. Heavy Concrete Floor Constr.		Butler Field House Indianapolis, Ind. Fireproof Construction	
	Calculation	Btu	Calculation	Btu	Calculation	Btu	Calculation	Btu
Cubical Contents of Space Heated	154,665 cu.ft.		173,948 cu.ft.		169,470 cu.ft.		5,149,906 cu.ft.	
Heat Loss per Hour: 80° Rise		738,327		678,472		712,407	60° Rise	5,844,405
Inside Brick Walls	3993 cu.ft.x100#x0.195 Btu x 4°	311,456	3170 cu.ft x 100# x 0.195 Btu x 4°	247,260			620,000# x 0.195 Btu x 4°	483,600
Steel Beams-Lintels-Columns	13,800# x 0.1175 Btu x 4°	6,448	34,593# x 0.1175 Btu x 4°	16,258			2,996,000# x 0.1175 Btu x 4°	1,408,120
Reinforced Concrete-Slabs-Beams-Columns			3,458 cu.ft. x 140# x 0.21 Btu x 4°	407,336	9,856 cu.ft. x 140# x 0.21 Btu x 4°	1,159,064	4,489,660# x 0.21 Btu x 4°	3,767,114
Plaster on Inside Partitions	336 cu.ft. x 90# x 0.2 Btu x 4°	60,192	756 cu.ft. x 90# x 0.2 Btu x 4°	54,432	1,336 cu.ft x 90# x 0.2 Btu x 4°	96,192		
Pine Wood-Floors-Joists-Studs, Etc.	3,329 cu.ft. x 30# x 0.467 Btu x 4°	186,536	1,084 cu.ft. x 30# x 0.467 Btu x 4°	60,747	386 cu.ft. 30# x 0.467 Btu x 4°	21,632	3530 cu.ft. x 30# x 0.467 Btu x 4°	197,821
Plumbing & Electric Pipes & Fixtures	Estimated	8,800		8,800		8,800		44,000
Oak or Hardwood in Furniture-Organ	561 cu.ft. x 40# x 0.57 Btu x 4°	61,396	561 cu.ft. x 48# x 0.57 Btu x 4°	61,396	561 cu.ft. x 48# x 0.57 Btu x 4°	61,396		
Pine or Softwood in Furniture-Organ	367 cu.ft. x 30# x 0.467 Btu x 4°	20,568	367 cu.ft. x 30# x 0.467 Btu x 4°	20,568	367 cu.ft. x 30# x 0.467 Btu x 4°	20,568		
Total Heat to Raise Temperature of Materials 4° F		655,396		876,797		1,367,652		5,900,655
Percentage Heat Absorbed by Materials to Heat Loss		89%		130%		192%		100%

First Evangelical Church, Indianapolis, Ind.

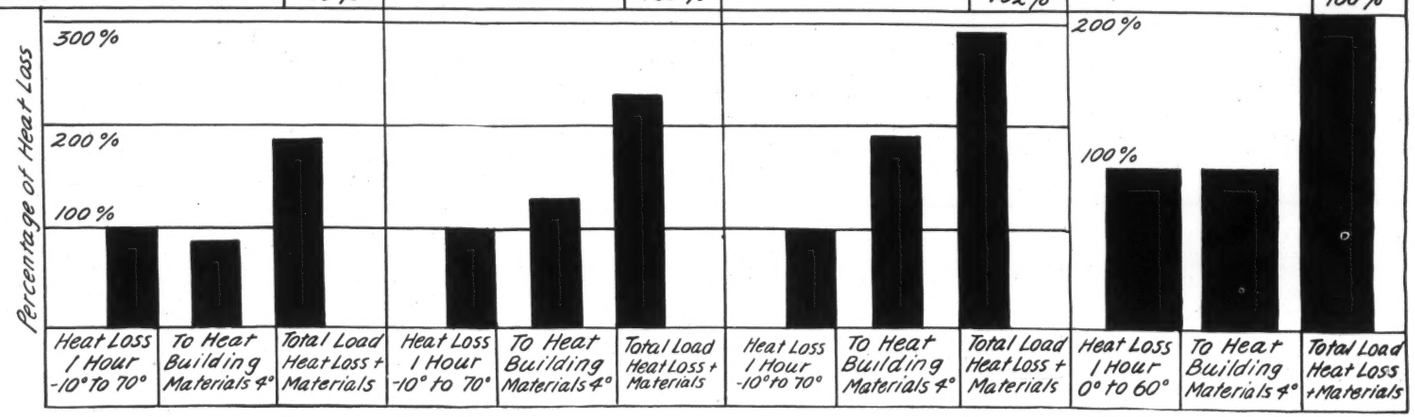

Percentage of Heat Loss
300%
200%
100%
200%
100%
Heat Loss 1 Hour -10° to 70°
To Heat Building Materials 4°
Total Load Heat Loss + Materials
Heat Loss 1 Hour -10° to 70°
To Heat Building Materials 4°
Total Load Heat Loss + Materials
Heat Loss 1 Hour -10° to 70°
To Heat Building Materials 4°
Total Load Heat Loss + Materials
Heat Loss 1 Hour 0° to 60°
To Heat Building Materials 4°
Total Load Heat Loss + Materials

Fig. 2—Graphic Comparison of Heat Loss with Heating-Up Load and Total Load for Four Buildings Heated Intermittently. Calculation of Heat Required to Raise Temperature of Inside Materials in Buildings Four Degrees Fahrenheit Is Shown Above

Inasmuch as all common building materials have not been tested, an average temperature rise of 4 F per hr. is assumed for all materials, for the sake of simplicity in the following calculations.

Load on Heating Plant Varies with Building Construction

Now, to illustrate the magnitude of the load on a heating plant to raise the temperature of all inside materials 4 F per hr., and to show how it differs with different construction, a calculation is made for three average-sized churches of equal cubical contents and nearly equal heat loss. The volume of all interior materials and furnishings was carefully measured in each building. No materials in outside walls or surfaces were included.

One church has wood joist and floor construction with about half the partitions of brick plastered on both sides and the other half of wood studs, wood lath and plaster. Another has 2-in. thick concrete floors supported by light steel rod truss joists with metal lath and plaster on the bottom of the joists, about half of the partitions of brick plastered, and the other half of wood studs, wood lath and plaster. The other church contains large masses of concrete with all floors of solid reinforced concrete slabs from 4- to 14-in. thick, and all partitions of wood studs, metal lath and plaster.

Heating-up Load for a Field House

Included with the three churches is a calculation of the heating-up load for the Butler University field house. In connection with other tests, accurate records of temperatures of air and inside materials were kept during the normal heating and cooling off of the building when used and heated one day a week. Within 48 hours after the heat is entirely shut off, all material in the building drops to a temperature within about 10 F of the average outside temperature. It is not permitted to go below 33 F but reaches that temperature nearly every week during the winter. In zero weather, the air in the building is heated from 33 to 65 F in about two hours, and the materials—steel roof trusses and concrete balcony—to 65 F within seven to eight hours, giving an approximate average rise in temperature of 4 F per hr. (See "Warm Air and Large Buildings," by E. K. Campbell, HEATING, PIPING AND AIR CONDITIONING, January, 1930.)

No Relation Between Heat Loss and Heating-up Load

The results of the calculation for the four buildings show clearly why services are dismissed in extreme weather in many churches equipped with heating plants that were designed carefully and correctly for the normal heat loss load but with not more than 25 per cent additional capacity for the heating-up load. They show why one building with wood floor construction heats easily and quickly, while another with large masses of concrete or masonry heats very slowly, when the heating-up load for each is calculated by adding an arbitrary percentage to the normal heat loss load. There is no relation between the heat loss load and the heating-up load for buildings of different construction, heated intermittently.

Accurate Temperature Control Needed

Nearly all buildings used intermittently accommodate large gatherings of people who are present for comparatively short periods of time. A large surplus of heat over the normal requirements must first be supplied to warm cold materials and seats, then when a room fills with people, the input of heat must be checked quickly and in many cases heat must be removed. It may be necessary to operate at full capacity one hour and to have all heat shut off the next.

SCRUGGS MEMORIAL M. E. CHURCH, SOUTH, ST. LOUIS

Chart for Pressure Drop in Low-Pressure Steam Piping

By Julius Hulman*

A COMMONLY-USED equation for determining the pounds of steam that will flow in a pipe under a given set of conditions is:

$$W = 5220 \sqrt{\frac{d^5\, p}{\left(1 + \frac{3.6}{d}\right) VL}}$$

where W = pounds of steam per hour
d = actual inside diameter of the pipe in inches
p = pressure drop in pounds per sq. in.
V = specific volume of the steam
L = equivalent length of the pipe in ft.

A convenient chart for low-pressure calculations is the 3-scale chart on the next page. Most heating calculations are on the basis of a steam pressure of 2 lb. per sq. in. gage pressure. The specific volume for this pressure (22.55 cu. ft. per lb.) has been substituted for V. The pressure drop is based upon a one-ft. length of pipe, eliminating the variable L.

The equation is thus reduced to the form:

$$W = 1101 \sqrt{\frac{d^5\, p}{\left(1 + \frac{3.6}{d}\right)}}$$

In any problem, knowing any two variables, the third variable can be found from the chart.

Use of Chart

The method of using the chart is explained in the caption, and requires only the use of a straight edge and pencil. It is not necessary to draw a line across the chart, but it is more convenient to do so.

Two facts must be noticed: First, that d on the chart indicates nominal size pipe, *A. S. T. M.* standard weight;

*Rose Polytechnic Institute, Terre Haute, Ind.

second, that, the W and p scales are lettered differently on the right and left sides. **Use left side of "W" with left side of "p," and right under-lined side of "W" with right under-lined side of "p."**

From the nature of the basic equation one can readily see that p varies as W^2, therefore, the quantities as lettered on the chart may be extended to any values encountered in practice. Moving the decimal point of the value of W one place to the right or left moves the decimal point of the value of p two places to the right or left.

Using the chart for the following problem:

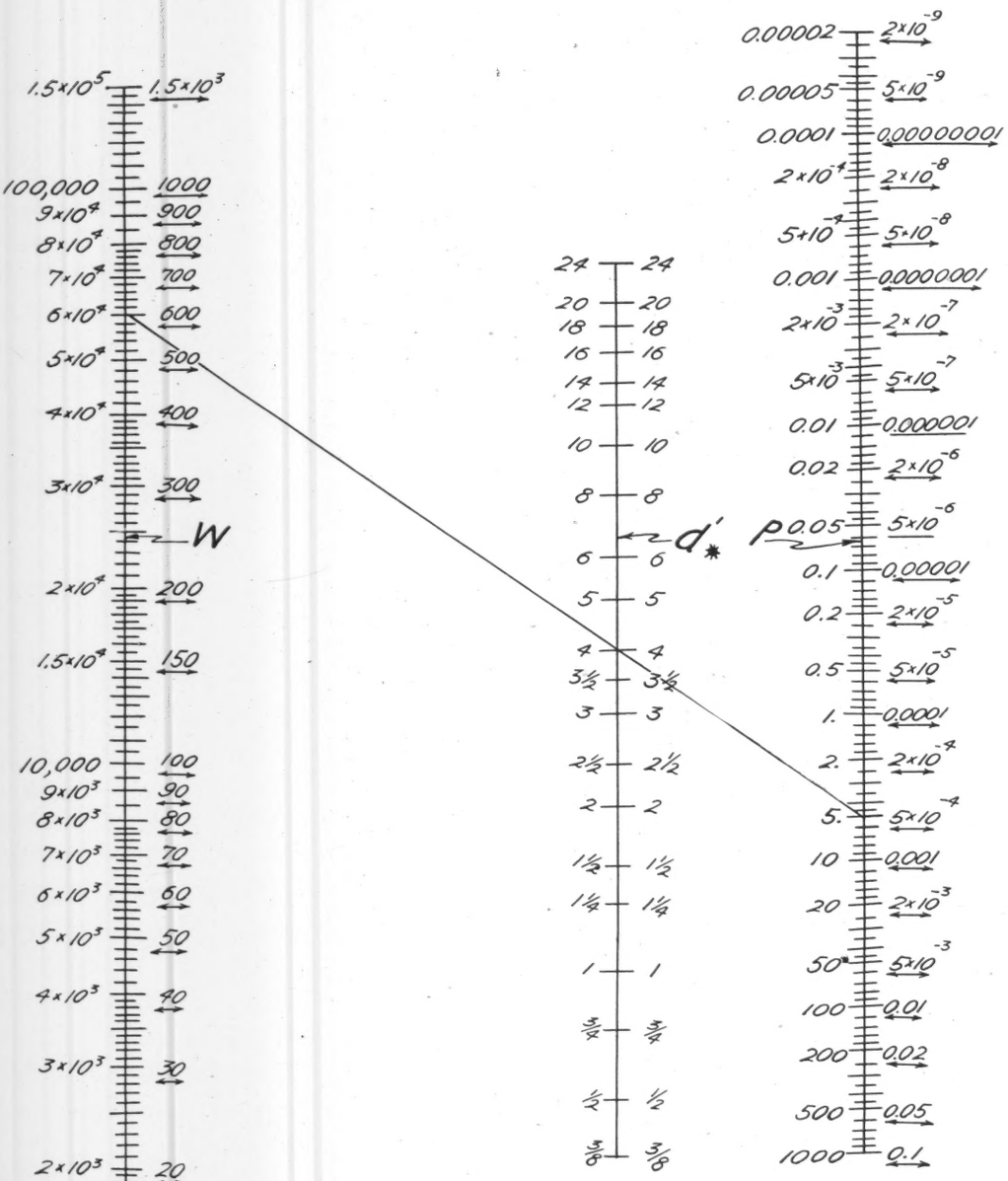
$W = 50{,}000$ lb. per hr.
$d = 24$ in.

From the chart

$p = 0.00036$ lb. per sq. in. per ft. length.

Then for 500,000 lb. per hr., $p = 0.036$ lb. per sq. in. drop per ft.

The foregoing discussion explains why the p-scale was extended to such seemingly absurd limits.



Examples of Use of Chart

Example 1: Determine the quantity of steam flowing in a pipe with pressure of 2 lb. per sq. in. $L = 330$ ft. = equivalent length; $d = 6$ in.; $p = 0.165$ lb. per sq. in. drop in 330 ft. or 0.0005 lb. per sq. in. drop in one ft. There are two lines which may be drawn to obtain W. It is more convenient to use the point 5×10^{-6} on the right side of scale p. Thus the answer read from the chart is 174 on the W-scale. Since the pressure drop is only 5×10^{-4}, then $W = 1{,}740$ lb. per hr.

There is a point 5×10^{-4} on the p-scale, but using this point will run the line off the scale, and so the value 5×10^{-6} must be used.

Example 2:

$W = 64{,}000$ lb. per hr.

$p = 0.003$ lb. per sq. in. per ft. length. Find d.

From chart, d is determined as approximately 18 in.

Correction Factor Enables Use with Higher Pressures

By utilizing a correction factor this same chart may be used for any initial pressure. From the equation it is seen that:

$$W_1 = W\sqrt{\frac{V}{V_1}}$$

$$W_1 = \sqrt{\frac{22.55\,W^2}{V_1}}$$

Subscript *1* indicates steam at any pressure, and no subscript indicates steam at pressure of 2 lb. per sq. in. gage.

The correction factor is $\sqrt{\dfrac{22.55}{V_1}}$ which multiplied

Chart for Pressure Drop in Steam Piping

$$W = 5220\sqrt{\frac{pd^5}{V\ L\ (1 + 3.6\ /d)}}$$

W = lb. of steam flowing per hr.
d = actual inside diameter of pipe, inches.
L = equivalent length of pipe, feet.
V = specific volume of steam
p = pressure drop in lb. per sq. in.

The chart is constructed with $L = 1$ ft. and $V =$ the volume of steam at a pressure of 2 lb. per sq. in. gage.

The equation of the chart becomes:

$$W = 1101\ \sqrt{pR}$$

$$R = \frac{d^5}{1 + 3.6/d}$$

Use of Chart

Knowing two of the variables, draw line connecting the two and extend line to third scale. This intersection is the answer.

NOTE: Always use right hand underlined side of W with corresponding side of p *scale.*

**d*' is nominal size pipe, *A. S. T. M.* standard.

Moving decimal point of W moves decimal point of p two places in same direction.

When $W = 600 \quad - 6000 - 60$
$d = 4 \quad - 4 - 4$
$p = 0.00055 - 0.055 - 0.0000055$

by W as read from the chart gives the actual pounds of steam flowing.

The correction factor for p when any other pressure is used is $V_1/22.55$.

$$\frac{V_1}{V} = \frac{p_1}{p} \text{ or } p_1 = \frac{pV_1}{V} = \frac{p\ V_1}{22.55}$$

That is, knowing W and d, p is found in the usual manner, and then multiplied by $V_1/22.55$, giving the actual pressure drop.

An Example

$W = 200$ lb. per hr. Steam pressure = 50 lb. per sq. in. abs.
$d = 2$ in. $V = 8.514$ cu. ft. per lb.
$L = 500$ ft.

From chart, p=0.0025 lb. per sq. in. pressure drop per ft.

$$\frac{500}{}$$

1.25 lb. sq. in. pressure drop for 500 ft.

$$p = \frac{1.25 \times 8.514}{22.55} = 0.47$$ lb. per sq. in. pressure drop for 500 ft. length and pressure of 50 lb. per sq. in abs.

The chart presented is a very simple one, and one which should be satisfactory to the engineer having a great many pressure drop calculations to make. It is based on a rigidly accurate method of development. Any errors in the results obtained are mechanical errors, introduced in the mechanical construction or usage.

English — German — French Dictionaries Published

Hoyer-Kreuter Technical Dictionary. Sixth Edition. Three volumes; three languages; 2295 pages (total), 7¾ by 11 inches. Published in Germany; agent in the United States, The Industrial Press, 148 Lafayette St., New York City. Price, for the three volumes, $55; for two volumes, $37.50; for one volume, $19.50.

The Hoyer-Kreuter technical dictionary has been published in a new and enlarged edition (the sixth) including 100,000 selected technical terms embracing various industries, arts, and sciences. This work is in three large volumes: German, English, French; English, German, French; and French, German, English. Volume 1 has the German words alphabetically arranged, with definitions following in both English and French; Volume 2 has English entry words, with definitions in German and French; and Volume 3, French entry words. About 44,000 terms have been added to the sixth edition to cover new developments in science and industry. Dr. Alfred Schlomann is the editor; the publisher is Julius Springer of Berlin.

Tests of Joints in Plates Reported

"Tests of Joints in Wide Plates" is the title of Bulletin No. 239 recently published by the Engineering Experiment Station of the University of Illinois, Urbana. It is the report of an investigation conducted by Wilbur M. Wilson, James Mather, and Charles O. Harris.

Quoting from the introduction "The object of the investigation was to determine the efficiency of various types of joints in wide plates as used in the construction of storage tanks for water and oil. The investigation included tests of: (1) riveted lap and butt joints; (2) joints for which holes were drilled and others for which they were punched; (3) joints with rivets in single shear and others with rivets in double shear; (4) welded joints, both lap and butt; (5) joints having rivets supplemented with welds; and (6) wide plates containing no joints." The section of the plates varied from 40 in. by ¼ in. and 20½ in. by ½ in. to 72 in. by ⅝ in.

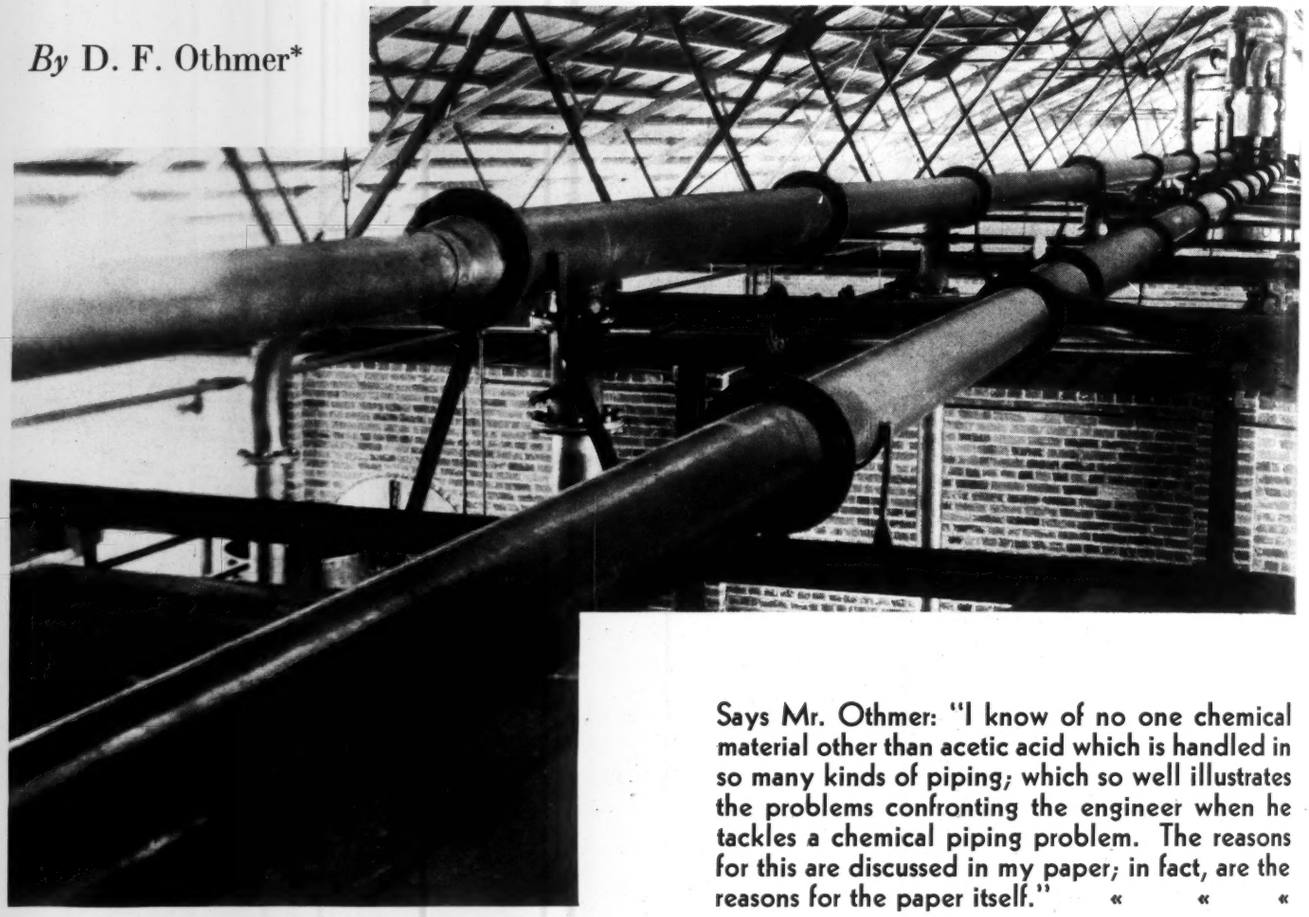
The bulletin consists of 74 pages, 6x9. Its price is forty cents.

Handbook on Gas Heating Issued

The "Engineering Handbook for Building Heating by Gas" has recently been published by the New Jersey Gas Association, 80 Park Pl., Newark. According to the industrial and house heating committee of the association, of which H. P. Morehouse is chairman, it has been the endeavor to include only such information, tables, charts, data and formulas as were felt necessary for the majority of installations and to make the book capable of expansion for individual tastes. The book is of convenient pocket size and is loose-leaf in form.

The chapters included in the book are determination of heat loss of buildings, steam and hot water heating (calculation of radiation required, piping and selection of gas-fired boiler), warm air heating (gravity and fan), estimating gas consumption, automatic gas burners, water heating, industrial and commercial building heating, data on various fuels, and physical units and tables. Its price is $2.00.

By D. F. Othmer*



COPPER LINES FOR CARRYING PYROLIGNEOUS ACID VAPORS AND GASES, CONNECTING RETORTS, CONDENSERS, AND GAS SCRUBBER

Says Mr. Othmer: "I know of no one chemical material other than acetic acid which is handled in so many kinds of piping; which so well illustrates the problems confronting the engineer when he tackles a chemical piping problem. The reasons for this are discussed in my paper; in fact, are the reasons for the paper itself." « « «

Problems in Piping Chemicals Typified by Acetic Acid

PIPING, pumping and handling of acetic acid becomes of increasing importance every year as the older uses expand, and newer uses multiply and grow. No simple chart or table can indicate the rise and fall of acetic acid production, either collectively by all of the systems used for the manufacture of this material of many relatives and metamorphoses, or individually by any one. This is because of the interdependence of raw material and finished product in most of the uses of acetic, often giving rise to the uncertainty as to which is the starting material and which is the product; and also, because there is a lack of statistics available for the different producers.

Methods of Production

Acetic acid is produced at the present time in three principal ways: (1) fermentation of vinegar: apple, grain, and molasses, always with the intermediate production of alcohol, although bacteria of prohibitionist proclivities have been unsuccessfully sought after to accomplish the fermentation in one step; (2) distillation of hard wood (pyroligneous acid or wood vinegar); (3) synthetic chemical processes using acetylene from calcium carbide and the electric furnace, and through acetaldehyde and an oxidation process. Several fourth processes are in the offing. Direct synthesis, starting from the basic materials, coal, lime, water and air, accounts for most of the increasing production at the present time.

Piping Material Must Be Carefully Chosen

The piping and other equipment for transporting and handling the acid liquids encountered in all of these ramified operations must be carefully chosen, depending on the strength of acid and especially on the other materials in solution besides water—even though these impurities may be present only in very small amounts.

*Consulting engineer, Rochester, N. Y.

Different ranges of acid concentration have widely different corrosive action on metals and the presence of even a fraction of a per cent of other acids or their salts may increase the destructive action a hundredfold.

In addition to the number of different materials of construction which are necessarily used because of the different aspects of the corrosion problem, each different industry—and especially is this true of the older ones—has developed its own methods independently of the others, and by a process of growth and heritage has established its own preferences and standards.

Acetic Acid Inflammable When Anhydrous

Quite aside from the corrosive attack of acetic acid, by which is to be understood its action as an acid on metals, the solvent action of this versatile liquid on various other materials of construction is of importance. Acetic acid, especially when anhydrous, or nearly so, may be considered as a solvent comparable to alcohol, ether, or acetone. Like them, and particularly when heated, it may dissolve or disintegrate packing materials, wood, and other fibrous or plastic bodies which may be used in the construction of pipes, lines, pumps, or other equipment. Acetic acid, as would be expected from its chemical similarity to these other solvents, is inflammable when anhydrous; and, especially when it is heated and vaporous, precautions must be taken in its handling the same as with most other organic liquids.

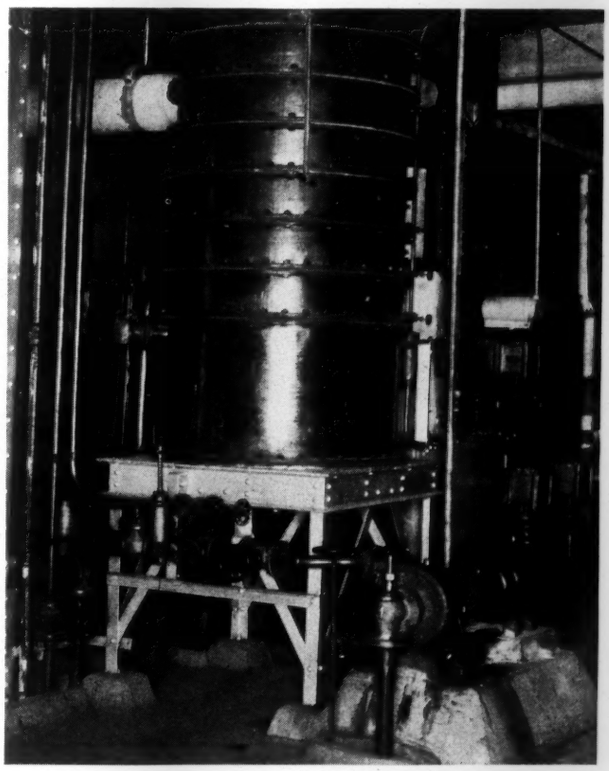
Use of Wooden Pipe

The oldest methods for the production of acetic acid are those of the fermentation industries; and these follow the lead and use the methods to some extent of that parent of chemical commerce, the manufacture of alcohol; tight wooden barrels and kegs for shipment, wooden tanks for cold processing and storage, and wooden pipe lines for conveying. The pipe lengths have fitted ends which depend for their tightness on the swelling of wood when wet; these pipes are attached by socket connections which swell to a sound joint. The elbows and tees, likewise, are formed by drilling blocks of wood. Wooden stave construction of pipe lines as well as tanks is suitable where higher pressures or larger quantities are encountered than can be handled in bored log pipe, and piping so constructed may be installed in a single continuous length without sections, much as a masonry aqueduct would be built in place, but without the need of a cement or other binding material to make the joints tight. The individual members are held firmly in position with wire windings; and the wet swelling of the wood makes the whole construction tight against leaks. Either the drilled or stave lines when reinforced with these wire windings may be used with pressures up to 100 lb. per sq. in. in moderate size pipe. Besides the cheapness of wood, and the ease of fabrication and making joints, an important advantage is the thermal insulating properties of this natural resistor to the flow of heat. This is a consideration both for the protection against freezing in cold climates and, also, for the prevention against heating of the liquid in some processes where an artificially-refrigerated acid is to be transported. Wood, either for tanks or pipe, is not usually used with hot acids; and in acid concentrations above twenty-five per cent the disintegration and shrinking of wood is rapidly accomplished by hot acetic acid and, in some cases, by the cold acid. Wooden pipes and tanks, and wooden tank cars used for the transport of anhydrous acid, may develop leaks due to shrinkage of the staves caused by the solvent action of this liquid on the wood fiber.

Rubber Hose and Pipe Finds Applications

Rubber hose has an extensive use in handling vinegar between pumps, tanks, filters, and other equipment. It is not usually installed permanently, but is moved from place to place as needed. It has an excellent length of life with vinegar at any temperature normally encountered; and because of its portability and the ease of cutting out worn sections, rubber hose, when it may be used, gives a good return on the necessary investment. In the acid-proof grades, rubber tubing is available in sizes up to ten or twelve inches in diameter. Hard rubber pipe and fittings are also used in special applications, such as generator heads for measuring, controlling, and distributing the liquid flow to the vinegar generators. Hard- and soft-rubber-lined wood and steel containers are also used for storage and transportation of acid of intermediate strength.

Rubber diaphragm or pinch valves are in use with dilute acid of vinegar strength on low pressure pipe lines of various metals. These consist essentially of a short length of specially-shaped soft rubber tubing encased in a metal body. The handle and stem, which does not extend through a packing box, forces an upper plate down to squeeze the two walls of the tubing together to stop liquid flow. The tube walls in this short section are parallel planes and the action is the same as pinching a small rubber tubing with the fingers or a small pinch clamp, but on a greatly magnified scale since

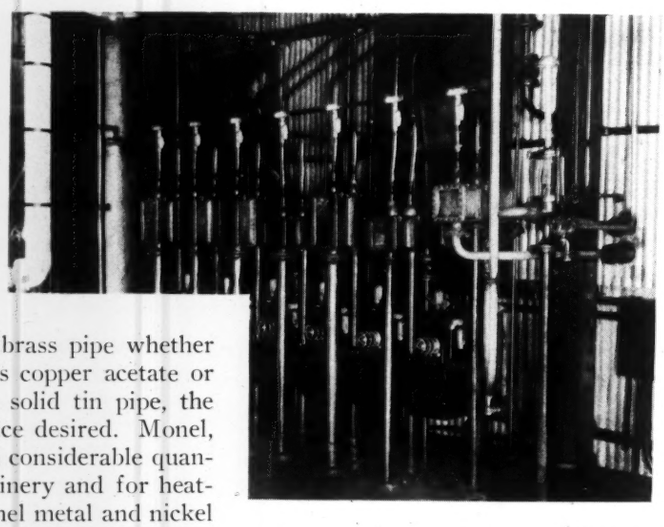


DETAILS OF BASE OF COLUMN SHOWING TYPE OF PUMP, VALVES AND CONTROLS

these valves are used in sizes up to several inches diameter.

Metallic Piping Materials

Besides these two non-metallic materials, wood and rubber, the vinegar industry uses iron, brass, copper, nickel, monel metal, tin, and the various grades of stainless steel. When used with vinegar or other fruit or fermentation acids, the factors considered in connection with wrought iron or mild steel pipe are suitability and length of life, with copper and brass pipe whether there is danger of forming poisonous copper acetate or verdegris, and with monel nickel or solid tin pipe, the cost in relation to the length of service desired. Monel, nickel and solid tin piping are used in considerable quantities for short lines connecting machinery and for heating tubes, valves, and specialties. Monel metal and nickel form no poisonous compounds and have satisfactory life with dilute acid. Silver has been occasionally used, usually in the form of silver plate over copper.



Look-Box Station, Showing Aluminum Box and Piping (On Right) for Strong Acid

Much promise is indicated by some of the newer stainless steels of the 18-8 variety which, with hot vinegar, have been used in one installation for over a year without sign of corrosion. The stainless steel fittings for such work are comparatively expensive at the present due to the small quantities in which they are produced, but because of their resistance to corrosion their use is recommended on many new installations.

In the wood distillation industry, a standard material for piping all strengths of acetic acid below the anhydrous grade is copper. In some cases, the protective action of a film or layer of tar settling from the pyroligneous acid on the inner surface of tanks, although not usually of pipes, so reduces the corrosive action, that cast iron or steel are quite satisfactory.

Copper: In the smaller sizes, copper pipe is made up with standard threads and cast copper or bronze fittings, and in sizes above 3 in., of seamless copper tubing with Van Stone flanges made up on the job and having cast iron or mild steel backing flanges. Another type of copper piping, which has been experimented with and has several advantages for use with smaller size lines, is the compression fitting type. This utilizes soft copper tubings supplied in rolls, is fitted with slightly funnel-shaped ends expanded on the tubing ends by a special tool on the job and, for connecting lengths, utilizes special copper or bronze fittings somewhat similar to ordinary unions for iron pipe.

It is also becoming a widely-used practice to fabricate copper pipe lines by welding or brazing tubing in place and to use forged copper elbows, reducers, and bends, in the same way, and in the usual case, with the same standards as have recently been developed for the welding of steel pipe lines. Pipe lines utilizing as much as several miles of pipe are to be found so constructed.

For those strengths of acetic acid higher in acid than vinegar or pyroligneous acid, and including the liquids encountered in the synthesis from calcium carbide and acetaldehyde, a usual material of construction is copper. Copper is used for pipe lines and equipment which may be fabricated from plates, because it is easily worked. Copper has satisfactory life at all strengths and temperatures of acetic acid if the liquid is free from dissolved air or oxygen. In closed pipe lines or equipment handling acetic acid free from dissolved gas there is practically no corrosive action, if no impurities are present. In distillation pipe lines and equipment, the corrosion by acetic acid, in the absence of other impurities, of copper units, which are protected against the presence of air by continuous operation and other precautions, is practically nil.

Vent lines on such equipment, although not in contact with the heated vapors or liquids, may have to be replaced, however, due to the attack of the small amount of comparatively cold acid vapor when mixed with a much larger amount of air. Neither copper lines carrying warm or hot acetic nor copper stills used with acetic will discharge a water-white acid before all of the air in the system has been eliminated; until then they will pass an acid colored with blue copper acetate, first of an inky blue nature and then, as the air is gradually removed, of lighter and lighter tints. Recovery systems which involve the condensing of acetic acid vapor from air, or other systems in which acetic acid vapor is mixed with air, may be rapidly destroyed due to this oxidizing action.

Silver, a close chemical relative of copper, is relatively unaffected by dissolved oxygen. It, like copper, is readily workable, but its cost has kept it from extensive use, except for small specialties. Copper tubing in sizes of 2 in. and above has been successfully silver plated on the inside to give excellent resistance to hot acid vapors mixed with air.

Cast iron of high silicon content is practically unaffected by acetic acid at any temperature or concentration, even when the liquid is saturated or the vapors mixed with air or oxygen. It has been used under se-

vere conditions in pipe lines of considerable length. Pipe lines when correctly installed of this material have excellent length of life with acetic acid liquids of the compositions normally encountered. With the development of a somewhat stronger and less brittle silicon iron in the last years, its use has been extended. It is often the practice to use valves of high silicon iron in diameters up to 4 in., even when the line itself is constructed of copper and has flanged ends. Valves of this very hard material are cheap and are not readily affected by wiredrawing.

Stainless Steels: With acids above vinegar in strength, lines of the so-called stainless steels have been extensively used. The present practice of using stainless steels of low carbon content and improved welding technique permits the advantages of these steels to be realized in welded pipe lines. One company is replacing a very large distilling system for strong acid handling, with columns, piping, and fittings of a stainless steel of the 18-8 variety.

Lead: The use of lead, as a material of construction in lines and equipment for many acids other than acetic, has been very widespread. Lead, because of its poor mechanical properties, lack of strength and high density, as well as its comparatively poor resistance to corrosion by acetic has limited application.

Aluminum: In the range of anhydrous or glacial acetic acid, so called because the pure acid freezes to ice-like crystals at 16.6 degrees Centigrade (61.9 F), other materials of construction are much in evidence. Pure acid, containing less than about four per cent water, has practically no effect on aluminum, but larger amounts of water greatly increase the rate of attack, although in many cases do not prevent the satisfactory use of this metal. Formic acid, present as an impurity in amounts down to a fraction of a per cent, causes a rapid destruction of pipe lines of aluminum handling any strength of acid. Where this impurity is not present, the use of aluminum is preferred for piping and storing glacial acid. Aluminum condenser tubes, for glacial acid not containing formic acid, are usually good practice, if the cooling water is not alkaline. If the water is even slightly alkaline, aluminum tubes may be badly corroded and pitted within a short time.

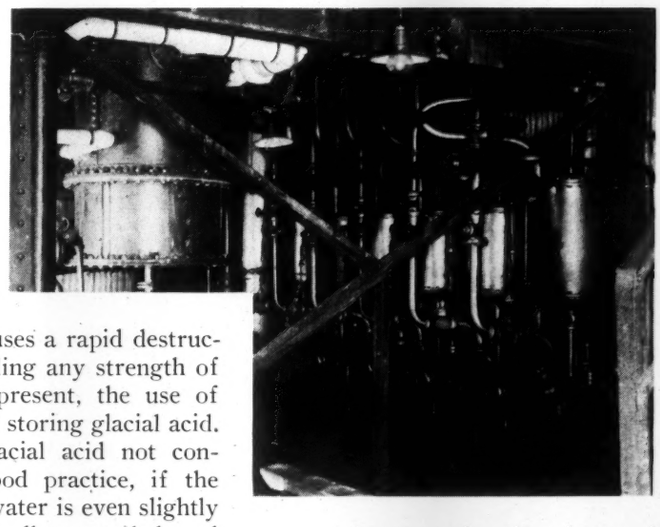
Silver tubing and condensers have been standard practice for a great many years for this strong acid, and instances are known where such equipment has been in service for at least fifteen or twenty years. Storage vessels, pipes, and cocks of chemical stoneware are in use for handling this grade of acid, as are also pipe lines of glass tubing joined with rubber sleeves or special glass flanges.

One installation, in which it was necessary to have combustion gases in direct contact with tubes containing acetic acid vapor under pressure, was designed with a combined or double tubing consisting of a nickel tube drawn over and fitted so tightly to a central copper tube that separation was practically impossible. The inner copper tube carrying the vapors was reinforced against the internal pressure and protected against the oxidizing effects of the stack gases by the nickel sleeve. This same construction is now available with stainless and ordinary steel piping, in which either the inner or outer pipe layer is made of acid-resisting nickel-chrome steel; of pure nickel and steel; and, for other uses than with acetic acid, of lead and steel.

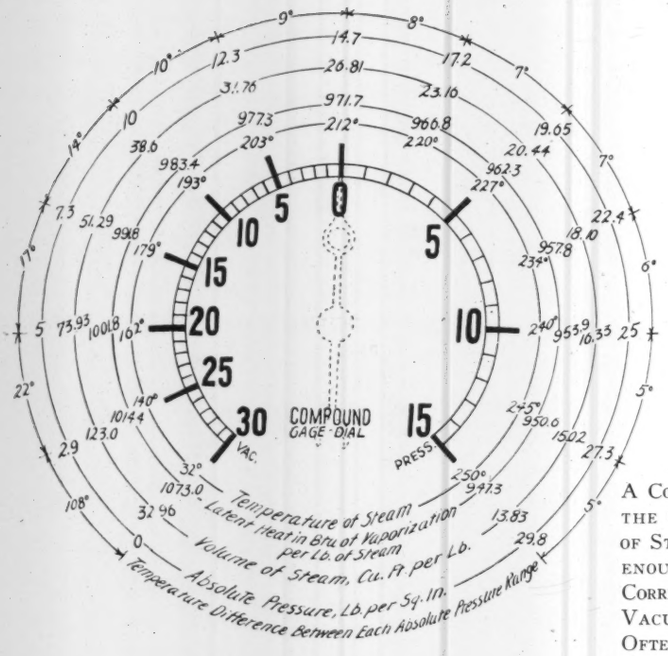
Tantalum has an almost perfect resistance to acetic acid under all conditions, and with any of the impurities encountered in technology. While this costly metal will probably never be used for pipes for transporting acetic acid, it is being considered for lining piping used in reaction vessels for organic chemicals involving acetic acid, and has been used for lining tubing carrying other corrosive acids. An arduous task has been the development of methods of making it available in a thin coating on the surface of cheaper metals which give mechanical form and strength. This metal, strong, ductile and chemically inert, is rolled into sheets a few thousandths of an inch thick; formed into tubes, which are electrically welded down an almost perfect seam; and hydraulically stretched to line snugly the inside of heavy walled tubing of baser and cheaper metal.

Electroplating Tantalum

Tantalum itself, because of the very difficulty of dissolving it, has resisted attempts to electroplate it. The usual methods of making a corrosion resisting film of one metal on another by electro-plating are reversed: the thin covering film is made first in the shape of thin welded tubing or other form; and a cheaper metal, such as copper, is heavily plated on one side or another until the desired thickness and strength is obtained. Thus tubing of tantalum is now electroplated, either externally or internally, with the desired thickness of cheaper metal; and a piping installation with very good resistance to any concentration of almost any acid mixture can be made.



Automatic Control and Pump Station for Acid Stills, Showing Piping Details


COMPOUND
GAGE DIAL
VAC.
PRESS.
Temperature of Steam
Latent Heat in Btu of Vaporization per Lb. of Steam
Volume of Steam, Cu. Ft. per Lb.
Absolute Pressure, Lb. per Sq. In.
Temperature Difference Between Each Absolute Pressure Range

A Compound Gage Dial, with the Corresponding Properties of Steam (According to Goodenough) Noted Opposite the Corresponding Pressures. Vacuum Pump Troubles Can Often Be Avoided If the Properties of Steam Are Known

By . . . . . John A. Masek

Not infrequently the vacuum pump is blamed when it is not at fault. This article points out some of the things that may be wrong with a vacuum return system which is not functioning properly; locating a leak or other defect promptly and correctly will save time and money.

Locating "Vacuum Pump" Troubles

IN ANY discussion of "vacuum pump troubles" it is necessary to consider the other parts of the system; in order to trace the *apparent* pump trouble to its source; frequently the piping or specialties may be at fault.

Reduction of Vacuum

When there is a loss of vacuum, the pump is sometimes suspected of being defective. While this may be the case, it is often due to high steam pressure which will give a high return condensate temperature. Vapor pressure and re-evaporation of part of the condensate will reduce the possibility of carrying a high vacuum. This is not necessarily a sign that the traps are leaking steam in the return piping.

Occasionally a piece of scale will stick in the orifice of a trap and cause the steam to shoot into the return. A leaky or defective check valve at the pump might destroy the effect of vacuum.

A worn air rotor, centrifugal pump impeller or jet nozzles will cause a decrease of vacuum. Pieces of scale or dirt may become lodged within the pump parts or impeller runner which will cut down the efficiency of the pump.

Air Leakage

Air leakage can sometimes be traced to expansion joints, which should be inspected frequently and repacked if necessary. Sand holes in fittings or the porosity of the iron may be another source of air leakage. This can be detected by applying a solution of soap and water on the suspected fitting. Drawing-in of the air bubbles will reveal a leak. Painting the porous fitting with asphaltum paint will generally stop small leaks while in some cases replacement will be necessary.

When an installation is comparatively new a breakage of fittings or at the pipe threads close to the fitting may give trouble.

Pump shaft glands may occasionally cause air leakage at the pump. These should be inspected and tightened when necessary.

This method may be used to locate hidden leaks: Disconnect the pump suction and connect a pipe line between the pump vent or air discharge at the top of the receiving tank with the diconnected return main of the heating system. In this manner the vacuum pump acts as an air compressor. A quantity of ether or oil of peppermint is allowed to suck in at the pump suction, which is left open to the atmosphere. With this arrangement the air laden with the fumes is forced into the heating system at from 5 to 15 lb. pressure. An inspection is made throughout the building to detect an odor escaping from a leak.

This was tried out in one hotel; it was found that the leak was caused by a nipple breaking off at the threads in between the walls.

A simple and positive way of locating air leaks, if conditions in the building will permit, is to fill the entire heating system with water. Any leak is detected by the leakage of water.

Radiator Traps and Valves

Trouble may be caused by leaky radiator traps or valves; these should be inspected and replaced if necessary.

Re-evaporation of Condensate

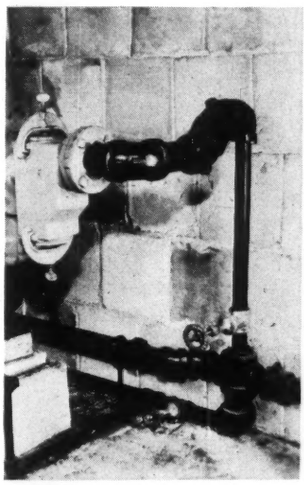
If the return condensate is unduly hot, say above 185 F, it indicates passing of steam or that the condensate from high-pressure apparatus is being discharged to the vacuum return. This will cause the water to flash into steam, corresponding to the vacuum maintained. Flashing or re-evaporation of return condensate is due to the lowering of the pressure on the water which lowers its boiling point. If the outside atmospheric barometer reading is 30 in. and 5 in. of vacuum is carried in the return lines the condensate will boil at 203 F, and will have a heat content of 171.3 Btu. A further increase of vacuum of, say, 10 in. would lower the boiling point of the water to 193 F and the water would have a heat content of 161 Btu. The difference of 10.3 Btu is used in re-vaporizing part of the condensate. To obviate this, a portion of the returns may be left exposed or uncovered so as to cool the pipe.

The value of having a thermometer installed in the return so the condensate temperature can be determined cannot be over-emphasized.

Pumping Condensate

The presence of lifts in the suction return line makes it necessary to maintain a vacuum at all times. Theoretically, 1 in. of vacuum will lift water about 1 ft., the maximum lift depending upon the temperature of the water.

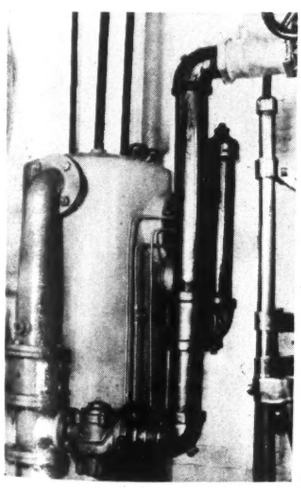
If an attempt is made to pump hot water any great height a higher vacuum must be exerted on the water which will naturally have a tendency to vaporize and limit the lifting capacity. If possible, returns should be arranged so the condensate will flow into the pump suction by gravity.



Lift Pipe Connection Which Lifts Condensate to Vacuum Heating Pump Receiver Tank

Lift Fittings

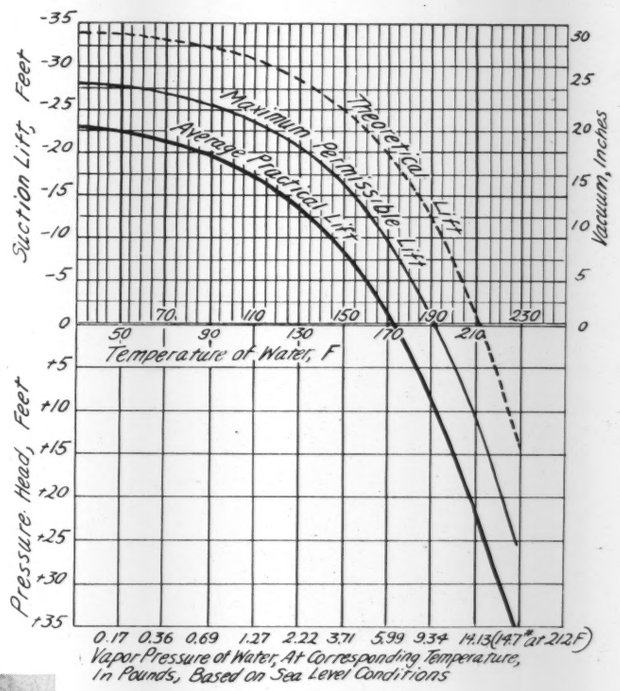
When necessary to lift water, lift fittings enable this to be done with a minimum amount of vacuum. The vertical lift piping should be one-half the size of the return piping, as trouble may be experienced if the lift piping is the same size as the return. A lift connection piping should not be over 6 ft. in height. When greater heights are required, the lift connection step may be repeated.



Air Chamber in Boiler Feed Discharge Line of Vacuum Pump to Absorb Any Shock and Avoid Water Hammer

Elimination of Water Hammer in Discharge Line

When there is a long discharge line, an air chamber should be installed close to the pump outlet to insure uniform flow and to eliminate pounding. Water hammer may occur when the boiler feed is discharged into a Hartford loop, particularly when the boiler water level is lower than the feed inlet. This can be overcome by installing an air chamber, consisting of a pipe about 2 ft. long and capped at the end.



Suction Lift Curves for Hot Water at Various Temperatures

Use of Boiler Compounds

A boiler compound treatment should only be applied to the type of boiler and system for which it is intended and in strict accordance with the directions. Boiler compounds should be poured into the boiler direct and not into the vacuum pump receiver tank as is often done.

While the pump may offer a convenient inlet, a strong alkaline or acidic solution will attack the brass pump parts and dezincification takes place—that is the zinc in the brass is dissolved.

Cutting Out the Pump

If for some reason interruption to the service of a vacuum pump is necessary and the pump is shut down the return line should be immediately by-passed to the boiler or the drain valve at the return header opened and the condensate wasted to the sewer. Delay will flood the return piping and water hammer result which may cause damage.

Proper Placing of Check Valves

On some vacuum systems the check valve in the piping at the pump may show excessive wear. Installing the check valve in a different location so that the swing flap will be submerged in the water instead of partly

in vapor or steam (which may cause a constant movement of the flap) will often correct this.

Float Mechanism of Pump

If the float mechanism on a pump gives trouble it should be repaired as soon as possible.

In one case improper functioning of the float caused water hammer in the discharge line that broke a 5-in. fitting and drained the water out of two boilers. If the attendant had not dumped the fire promptly the boilers would have been damaged.

Vent or Overflow Pipe Over Motor

The vent pipe from the vacuum pump receiver should not be placed over the motor. Motors have been burned out because the pump receiving tank became flooded, causing the water to drain on the motor. The vent pipe and drain line should always be brought to one side.

Some Typical Vacuum Pump Service Calls

Motor unable to revolve has been traced to fuses not being installed or burned out. The main switch may not be making contact.

Pumps not discharging water to the boiler due to neglect to open the gate valve. The check valve installed the wrong way or the swing flap loosened, plugging the discharge line.

Steam exhausting from the pump vent indicates an excessive steam leakage at the return traps or a main drip trap. A cold return pipe at the pump suction indicates an excessive air leakage. If very dirty water is being discharged by the pump it might be due to a buried suction line broken and sucking in dirt.

The motor rotating in the wrong direction will prevent the pump from functioning.

Wiring hook-up not made properly; pump vacuum regulator and float switch in series.

Thermal overload relays at the pump may cause the pump to stop due to external heat, say from the boilers or piping placed too close to the relay box.

Water leaving the boiler is sometimes caused by the condensate being held up in the return piping. This can be remedied by installing an equalizer line between the supply and return piping. A swing check valve in a seal or thermostatic return trap should be placed in the line. When a vacuum is created in the supply line on retarding fires the check valve or trap will automatically equalize the pressure difference and the condensate will flow by gravity to the lowest point in the return.

One manufacturer sent his service representative on a 500-mile call on a complaint that the vacuum pump would not pull a vacuum. Inspection revealed that there was an excessive steam leakage from a main drip trap. On taking the trap apart it was found that the wire holding the float in place during shipment was not taken off when the pump was installed.

Another manufacturer's service man made a 900-mile trip to prevent his pump from being taken out as unsatisfactory. The service man found that the float ball was stuck. On looking into the receiver tank he found it half-full of fine sand that had passed through the strainer. Washing out of the sand corrected the trouble; this confirms the advisability of draining the condensate into the sewer for some time before the pump is used.

Small Theater Solves Air Conditioning Problem With Ice

Many a movie theater has found the difference between profit and loss to be the installation of an air-cooling system. The public is attracted to theaters, stores, restaurants, etc., which offer them relief from the summer heat. In this article an ice-cooled system applicable to the smaller theater is described; the installation has been in successful operation—technically and commercially—for some time.

▼

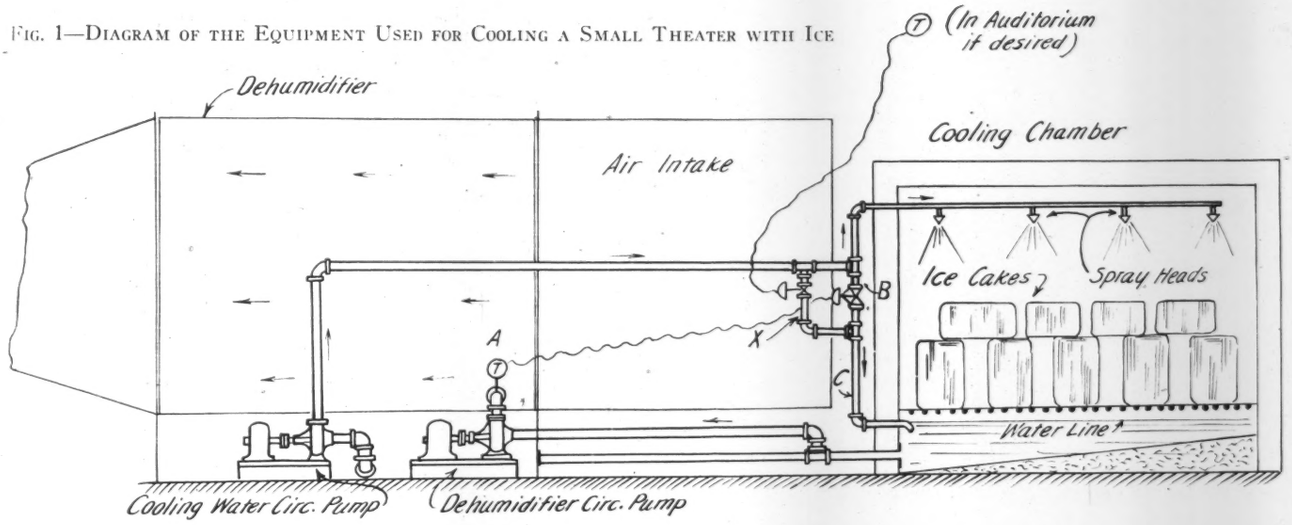
A METHOD of cooling that undoubtedly has an application to certain smaller types of theater is outlined in this article. It is not claimed that this system is suitable to larger theaters nor that the results are exactly equal. However, such systems are inexpensive to install and therefore can be used in small theaters which otherwise could not have cooling, and operating labor can be secured at low cost.

Lay-out of System in a Small Theater

It is interesting to see just what an ice-cooled system can accomplish in the type of theater to which it is particularly applicable. One theater in the Eastern part of the country has had one of these systems for some time and the manager is enthusiastic over the results attained. Of course, previous to this installation there was no cooling at all and this fact should be borne in mind.

The equipment used is illustrated in Fig. 1 and consists of a dehumidifier and air supply fan; the de-

FIG. 1—DIAGRAM OF THE EQUIPMENT USED FOR COOLING A SMALL THEATER WITH ICE



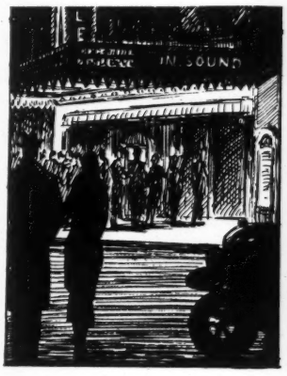
humidifier water is cooled by ice. A small return pump takes the water out of the dehumidifier pan and delivers it to a special cooling chamber where it is sprayed over ice blocks before it falls to the bottom of the chamber. There it is retained in a pan which is connected by a 4-in. pipe to the pan in the bottom of the dehumidifier.

Control of the Water

At *A* there is located a thermostat which controls a reverse-acting thermostatic valve at *B* in such manner as to permit a portion of the water to drop into the pan of the cooling chamber through pipe *C* (whenever the water gets too low in temperature) thus conserving the ice until the water temperature again rises to a point where it all must be sprayed over the ice. It will be noted that the dehumidifier circulation pump does not take its suction direct from the pan in the cooling chamber but on the contrary draws its suction out of a tee located on the 4-in. line which connects the two pans together. This permits the dehumidifier circulation pump to draw its water from the dehumidifier pan, if the cooling water pump is not in operation, and directly from the pan in the cooling chamber, when the cooling pump is drawing the water off the dehumidifier.

Cooling Chamber and Its Construction

The cooling chamber is insulated with about 9 in. of cork finished on the inside with 1 in. of cement and when the plant is not in operation the ice loss by melting is very small. Across the top of the chamber, piping is carried to sprinkler heads suitably spaced so that the water in falling covers practically the whole area of the chamber; size of the chamber is based on a capacity of 12 tons of ice. As this ice costs $3.00 per ton, it costs about $36.00 to charge the cooling chamber. As a ton of refrigeration is based on a 24-hr. period, if the ice were all melted in one day the capacity of the cooling chamber would be exactly 12 tons less whatever heat absorption takes place in the chamber. If the ice were all melted in twelve hours, the capacity of the cooling chamber would be doubled, or it would be able to supply 24 tons; again, if the ice were all melted in eight hours, the capacity would be 36 tons and if it only lasted six hours the capacity would be 48 tons.



Capacity of Plant

Many theaters now are being equipped with refrigeration plants based on a ratio of 60 tons per 1,000 seats with the question arising if 50 tons would not be adequate where a maximum of 15 F below the prevailing outside temperature is the greatest degree of cooling desired. This, of course, is for extreme weather; on this basis, the theater herein described with a seating capacity of 628 persons would require about

$$628/1{,}000 \times 60 \text{ tons or } 37.68 \text{ tons}$$

of refrigeration capacity in the hottest days of the year while, ordinarily, the load would be about 18 tons.

Therefore, with a full house in "dog days" the ice charge in the chamber would last about eight hours, and in ordinary summer weather the ice charge would carry over the entire day especially if there were periods when the house were not filled to capacity.

Providing Automatic Control

No attempt was made in this theater to provide automatic temperature control from conditions in the theater itself; the only automatic control is that shown in Fig. 1 on the water supplied to the dehumidifier which has the temperature automatically controlled from the thermostat located at *A;* it would be comparatively simple to install thermostats in the theater at several strategic points so that when all of these thermostats called for heat—in other words, if the theater got too much below the temperature desired—a diaphragm valve located in the by-pass pipe at *X* would open and cause the water supplied by the dehumidifier pump to be taken entirely from the dehumidifier pan until the necessary rise in temperature in the house had been secured. This would be independent from the control at *A* as opening the by-pass around *B* throws the thermostat action from *A* out of service.

Underground High-Pressure Steam Piping

By J. E. Hillemeyer*

SEVERAL factors in the construction details of the high-pressure underground steam line described in the March issue[1] are worthy of special comment and consideration on the part of those responsible for the construction of underground steam conduits in city streets.

The details as described in this article indicate that progress has been made in the distribution of steam underground; the methods employed to take care of the expansion in the conduit and to anchor the pipe lines securely in the manholes are an improvement on previous methods used, in our opinion.

Location of Tile Block[2]

The location of the 2⅛-in. vitrified tile block in the top of the conduit is questionable. If the rule pertaining to the best application of insulation is "Near to the highest temperature surface as possible" is followed, then the 2⅛-in. tile blocks should be located directly on top of the 20-gage corrugated iron sheeting, and the concrete poured over it. We see no construction difficulties in so placing the blocks.

Furthermore, since heat travels from a high- to a lower-temperature area (which in underground main construction means that the heat travels to the earth in all directions from the conduit) it would be just as logical to place a tile block barrier on the top of the base of the conduit as to place the tile block in the top of the conduit.

Some of the reasoning on the above suggestions follow:

Heat passes through all materials from a higher temperature to a lower at a rate depending upon the conductivity of the material and the temperature difference or potential across the material. Since the density of the common liquids and gases decreases appreciably with the addition of heat, a heat transfer motion is set up in this liquid or gas, the warmer particles tending to rise. For this reason the air at the top of a steam conduit is at a slightly higher temperature than at the bottom. Disregarding this small differential and assuming the insulation to be at least ¾ in. from the inside face to the conduit at all points, the temperature at the inside face of the conduit at all points will be the same. The heat transfer through the conduit material will then depend upon the temperature outside the conduit. Since ground water is often present in the drain tile adjacent to the conduit base, the temperature underneath the conduit should be somewhat less than on the other three sides. The conduit base and top should then be of at least as good an insulating material as the sides.

TURN IN LINE SHOWING REDUCER

"Open for Discussion"

Details of Construction of Underground Steam Piping Discussed . . . . A Chart Which Aids in Calculating Insulation

Insulating Rollers Shows Appreciable Saving

The idea of placing light-weight steel boxes around every roller support and packing this with loose rock wool to insulate these usually exposed points is a desirable improvement in underground construction practices. Our argument in favor of this practice follows:

Pipe guide rollers are commonly placed from 10 to 15 ft. apart. For a 20-in. pipe, about one sq. ft. of covering is cut away to provide contact area for the roller. The surface area of 12 ft. of 20-in. pipe is about 63 sq. ft. Then one sq. ft. of area with bare pipe loss and 62 sq. ft. with 5 per cent of bare pipe loss is equivalent to 63 sq. ft. with 6½ per cent of bare pipe loss. In other words, the effective efficiency of the insulation is reduced 1½ per cent by leaving one sq. ft. of surface bare for roller contact on 20-in. pipe. The loss is somewhat greater than this since the entire roller is at a higher temperature than the conduit air (due to conduction from the steam pipe) and an additional loss occurs.

Placing High-Pressure Traps in Separate Manholes

The practice of placing high-pressure traps in separate manholes adjacent to the main manholes housing the expansion joints, and then discharging the condensate from these low trap points through a flash tank and cooling pipe into the sewer, is also worthy of consideration and study. Our comments concerning this phase of the construction detail follow:

The additional cost of a manhole curb and cover and concrete for a small trap manhole placed just outside an expansion joint or conduit manhole slightly to one side of the line of conduit should be justified by the saving due to reduction of heat loss from the main. The re-

*Manager, Steam Heating Department, Union Electric Light and Power Company, St. Louis, Mo., and Vice-President, *National District Heating Association*.

[1] "Mile-Long Underground Line Supplies Steam for Process" by Robert L. Fitzgerald, HEATING, PIPING AND AIR CONDITIONING, March, 1932, pp. 180-183.

[2] In commenting on this discussion, Mr. Fitzgerald says: "I think the points are well taken, but do not agree entirely with the placing of the hollow tile directly above the conduit. We have had experience with this type of construction where the hollow tile was really used for the roof tile and this tile failed to show sufficient strength to carry the load. It broke in the center just above the pipe, opening a direct path for the water into the conduit. This type of construction could probably be used if special tile having sufficient strength to carry the load were used."

duction of vapor within the conduit not only reduces the conductivity of the conduit air but increases the life of the pipe insulation. The conduit air circulation would also be reduced since the number of times the conduit manholes are cooled by a fan would be appreciably reduced as traps are normally inspected and serviced more often than expansion joints.

Place Reducer Past Turn

It seems that the reducer in the line as shown in the article should have been placed at least six or eight pipe diameters past the turn in order to allow the turbulence in flow partially to abate before pipe reduction. Even if, at some later date, a manhole is to be placed at this point and a tap taken off, a reduction in pressure drop at this point would be realized if the original pipe size were carried past the tap.

Note on the Insulation of Piping

By A. F. Dufton, M. A., D. I. C.*

In the January number of HEATING, PIPING AND AIR CONDITIONING,[1] T. C. Patton describes a method of determining the economical thickness of insulation applied to piping. The method involves the determination of the economical outside radius R from the equation

$$R \log_{10} (R/r) = Z \qquad (1)$$

and for the solution of this equation the chart shown in Fig. 1 is provided.

A glance at this diagram shows that the scales are not simple ones and that they are inconveniently compressed at one end.

Equation *1* can be expressed in the form

$$\begin{vmatrix} 1 & 0 & -\log_{10} r \\ 0 & 1 & -Z \\ R & 1 & -R\log_{10} R \end{vmatrix} = 0,$$

which is the condition that the three points,

$$\begin{array}{lccll} & u & & -\log_{10} r & = 0, \\ & & v & -Z & = 0 \\ \text{and} & uR & +v & -R\log_{10} R & = 0, \end{array}$$

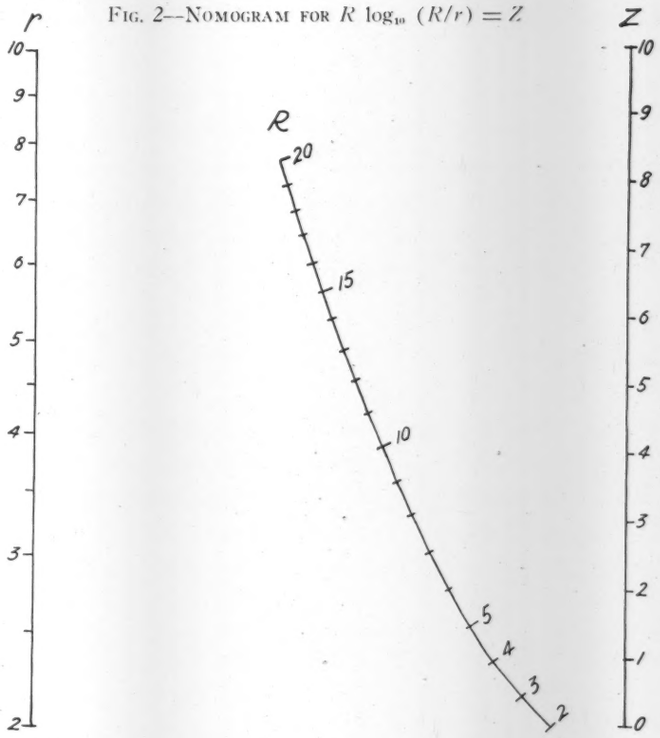
expressed in parallel co-ordinates, u and v, are collinear.

An alignment diagram, therefore, can be set out with two parallel scales, a logarithmic scale for r and a uniform scale for Z. Such a diagram is shown in Fig. *2*.

The scale of R was constructed automatically, each point being conveniently plotted as the intersection of the straight lines joining the pairs of points, $r = R$, $Z = 0$ and $r = R/10$, $Z = R$.

It is hoped that this nomogram will be of service to those who wish to use Mr. Patton's method and that it will help any who wish to construct a chart for their own use.

FIG. 2—NOMOGRAM FOR $R \log_{10} (R/r) = Z$



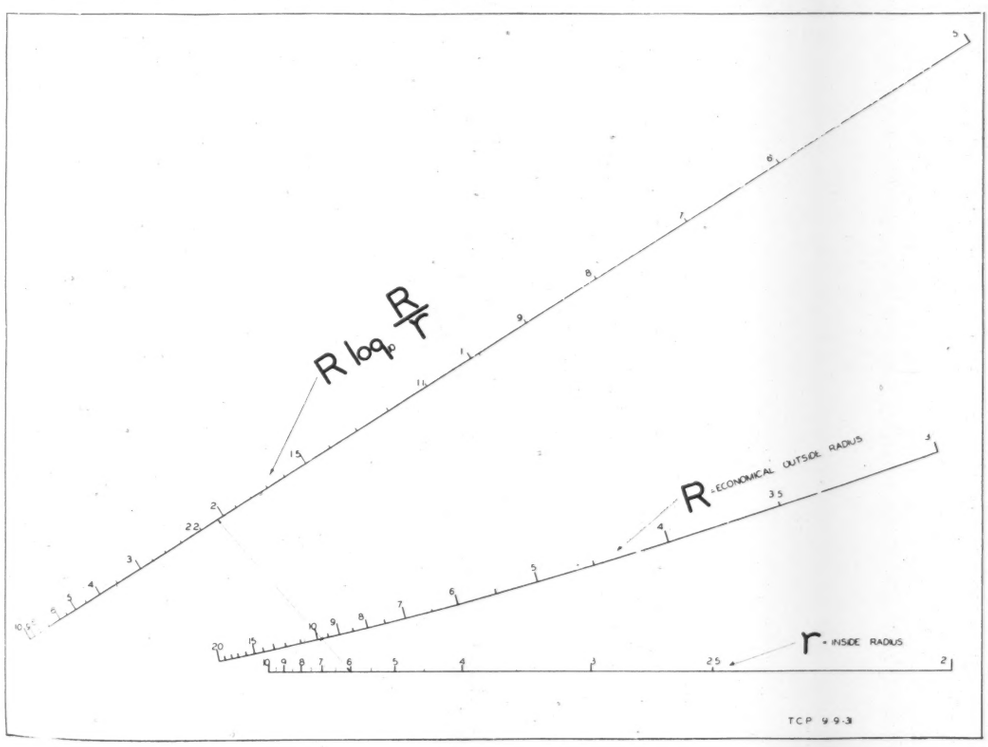


FIG. 1—IN DETERMINING THE ECONOMICAL THICKNESS OF INSULATION APPLIED TO PIPING, THIS CHART OBVIATES THE TEDIOUS PROCESS OF OBTAINING R (THE OUTSIDE RADIUS) BY SUCCESSIVE APPROXIMATIONS

[1] HEATING, PIPING AND AIR CONDITIONING, 1932, *4*, (1), 6.

*Director of Building Research, Department of Scientific and Industrial Research, Building Research Station, Garston, Herts, England.

By John H. Ruckman*

VENTILATORS CARRYING SULPHURIC ACID FUMES FROM THE CONTINUOUS RUN PICKLING DEPARTMENT OF A DETROIT PLANT

An ever-increasing list of substances and materials is being utilized in manufacturing processes and handled by industrial employes. Many of them are of such nature as to be slow-acting, but dangerous, poisons if breathed repeatedly.

Proper ventilation of industrial buildings is essential from this stand-point alone. Recovery is often advisable. In numerous cases, recovery of an air impurity has yielded a by-product which has paid—many times over—for the recovery installation.

This article points out a few examples which illustrate the need for proper ventilation and classifies some of the more prevalent impurities. « «

Preventing Air Pollution in the Plant

THERE are numerous substances and materials which tend, to an increasing extent, to contaminate air in manufacturing plants. One governmental agency has compiled a list of some fifty poisonous substances now in common use, but there are many others. Modern chemical reagents are, for the most part, substances which react strongly with organic compounds. When taken into the human organism they at once interfere with life processes. Such poisons may be absorbed into the body in many ways; one purpose of the industrial ventilating system is to insure that they do not reach the worker through the air he breathes, and in which he works.

How can this object be accomplished?

Prevention of accidental escape of clouds of poisonous substances is not a problem in ventilation but accidents of this type occur and the design and operating procedure of any plant must take them into account. One practical method of reducing the risk is to place dangerous units in the center of uninhabited areas, to provide selected personnel equipped with adequate masks, install a system of alarms, and train all hands regarding their duties in case of accident.

This solution is not always possible. Chlorine, for instance, is used in so many processes that cylinders cannot be kept out of buildings where men are at work, and the fumes generated by burning celluloid and collodian are often formed in crowded finishing rooms. This fact imposes certain conditions on the ventilating system. Obviously no system of circulation can be adopted which makes it possible for fumes suddenly generated in one room or building to be forced into another. It generally means that air sup-

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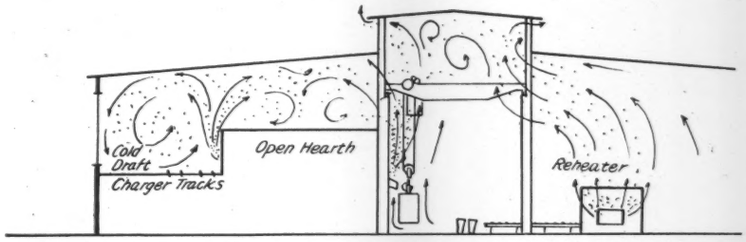


FIG. 1—CIRCULATION IN ROLLING MILL WITHOUT POSITIVE AIR SUPPLY

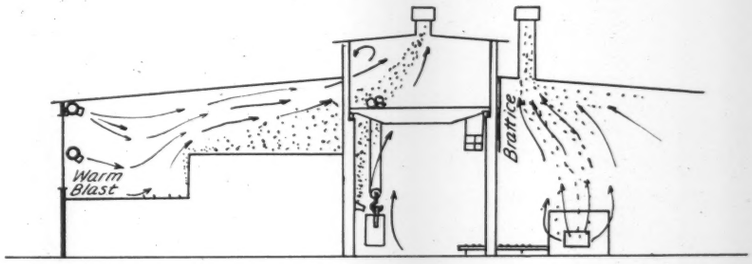


FIG. 2—CIRCULATION IN THE SAME MILL AS SHOWN IN FIG. 1 WHEN EQUIPPED WITH FORCED CIRCULATION, VENTILATORS AND DIFFERENT CRANE CONTROL

ply for each building must be a separate unit. Where an exhaust stack is used the draft must be strong enough to prevent reversal, and so far as is possible fresh air intakes should be placed where they are not likely to be contaminated. Expenditures for protection from unusual accidents must be determined by the principles governing insurance; they must take into consideration the probability of the accident and the probable results.

Chronic Pollution of Air in Manufacturing Plants

Disasters are fortunately becoming rare. Chronic pollution of the air due to leakage and intermittent escape, on the contrary, is increasing in most industrial districts.

The presence of carbon monoxide in foundries and steel works is an excellent example of this type of nuisance. It is liberated when beehive ovens are coking coal; it is liberated when the coke is waiting to be quenched and during the quenching; blast furnace gas carries about 25 per cent of it, some of which escapes through the charging hopper though most of it is piped back to the power plant for use in gas engines, or for heating. Exhaust gases from engines also contain it, as do those from converters, and open hearth furnaces. Smoke from locomotives which may be halted temporarily in or beside buildings contributes. How can this gas be eliminated? The usual suggestion is that the buildings be made high and "airy" with large doors. If this is the only precaution taken the buildings must be left practically open even in winter unless the crane operators are to be poisoned.

The first great step is, of course, the reduction of the amount of monoxide escaping. Practically all the combustible gas can be recovered and burned. Combustion is so regulated that a minimum of carbon monoxide is formed, and the waste gases are carried up through stacks. These must be high enough to insure that by the time the gases reach the ground the concentration will be so low as to be negligible. For a single small stack, a height of 50 feet may be sufficient, but where successive rows of large stacks are discharging, care must be taken to prevent cumulative pollution. As a further protective measure fresh air can be brought into many of the buildings and so distributed as to carry waste gases away from the men.

Supplying Fresh Air to Working Stations

This matter of delivering fresh air directly to the operatives can be given rather wide application. Gas producer chargers are continually poisoned by leakage from the charging door, and in water gas plants, gas escaping around the hood of the "blow up" stack makes trouble. In both cases a gentle blast of fresh air (at a comfortable temperature) directed toward the operative's usual working station will provide greatly increased protection. In many plants of this type, operatives leave the operating floor whenever possible and even in cold weather prefer to remain out-of-doors between operations, a custom which subjects them to sudden and dangerous changes in temperature. As indicated in Figs. 1 and 2 a supply of air at the proper point will greatly improve conditions.

Use of Hoods an Aid

Generally speaking, the proper answer to continuous and dilute poisons is fresh air at a gentle pressure in the building, hoods which come well down over the sources of poison and tall exhaust stacks. Practically all non-ferrous smelting works, most oil refineries and several rayon plants use a single exhaust stack, generally over 400 feet in height, which draws objectionable fumes from all parts of the plant.

Solvent vapor poisons are in some respects harder to deal with than are gases. As solvents are nearly always expensive, their escape to the atmosphere is undesirable from an operating cost standpoint, but certain types of manufacture make evaporation impossible to prevent. Thus nitro-cellulose when "spun" or extruded must generally be allowed to evaporate a little solvent (chiefly ether) from the surface of the filaments or it will tend to stick together again. In water-proof cloth manufacture the rubber solvent must be evaporated, and completely enclosed mechanisms cannot in all cases be used. Where solvents have been used, small quantities may remain for a considerable period in the final product and the smell may be detected even after the goods

are on sale by retailers. Of course, the first step in controlling these fumes is to obtain the maximum recovery. Vapor not taken into the recovery system tends to settle to the floor except as disturbances in the air lift and mix it. Enough will generally reach the air to be detected and if preventive measures are not taken, the amount reaching the operatives will be sufficient to cause some intoxication and will constitute a fire hazard.

Importance of Proper Circulation

Attempts to dilute ether fumes or carbon disulphide vapors are in most cases doomed to failure. Where benzene (benzole C_6H_6) is used sparingly it can be diluted but the exact dilution which when breathed continuously is entirely harmless is still undetermined. As with carbon monoxide and other poisons it is advisable to carry fumes away from the operatives' faces, preferably by gentle downward circulation. In designing such a system care must be taken that the actual circulation is in the direction intended. An example may suffice.

The building shown in Fig. 3 was designed to house a group of extruding presses and grain cutting machines in the manufacture of smokeless powder. The solvents used were ether and alcohol. The designer undoubtedly intended that the hot blast introduced in the monitor at a temperature of about 120 F should cool and at the same time be forced down reaching the floor at a temperature of about 60 F, expelling the ether fumes through the scuppers. It will be noted that the press charger was in a position somewhat similar to that of many crane operators, his head being nearly half-way up the building and in a zone where the temperature was generally in the neighborhood of 90 F. In order to receive raw material it was necessary for him to open the doors opposite his platform, and as a sniff of the outer air was a great relief, press chargers tended to keep doors open in spite of orders, reprimands and penalties.

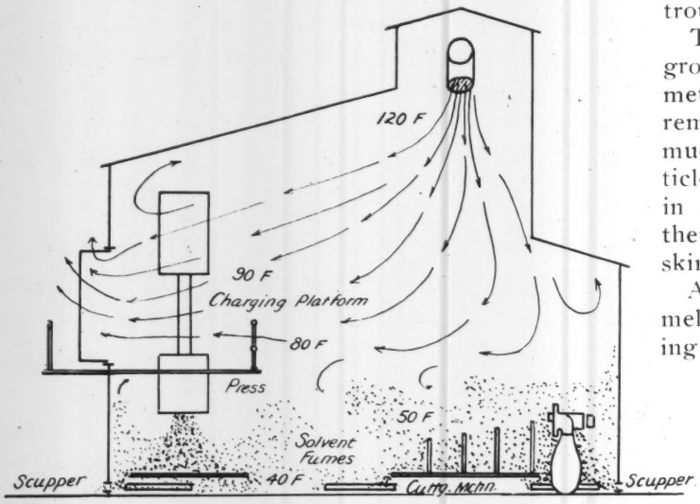


FIG. 3—PROPER CIRCULATION OF AIR WAS PREVENTED WHEN THE DOORS AT THE CHARGING PLATFORM WERE OPEN

Partition Improves Circulation

The intended circulation was thus destroyed, and the hot air short circuited. The lower floor became so cold that the cutting machine operators' fingers were numbed while ether concentration reached a point which caused general intoxication. The condition was relieved by placing a light partition or brattice from the press chargers' platform to the monitor, as shown in Fig. 4. The air was then forced down to the floor, leakage was sufficient to keep the charging platform comfortable and the ventilating system functioned as intended.

Dusts and Fogs

Dusts and fogs represent perhaps the most difficult problem for the ventilating designer. Yet probably more progress has been made during the last ten years in eliminating dust than in any other branch of industrial hygiene. Wet grinding has tremendously improved conditions in the first processes of portland cement manufacture, for instance. The introduction of air-tight tube and ball mills and the pneumatic and hydraulic transportation of dusts in air-tight conduits has also aided. Exhausts on abrasive wheels and buffers have greatly reduced sharp particles in interior air while electric precipitators and bag rooms have eliminated many out-door fumes. There are, however, many dusts which still cause trouble.

The troublesome materials fall roughly into two groups. One of these is represented by finely-divided metallic oxides and non-metallic anhydrides, which remain long suspended in air and which behave very much like vapors. The second type are larger particles which settle quickly enough but which occur in such a manner that men are liable to work in them, and absorb poison either through the lungs or skin.

Among the fumes, those of zinc given off by brass melting furnaces and ladles, and the cyanogen-carrying vapors developed during some types of case har-

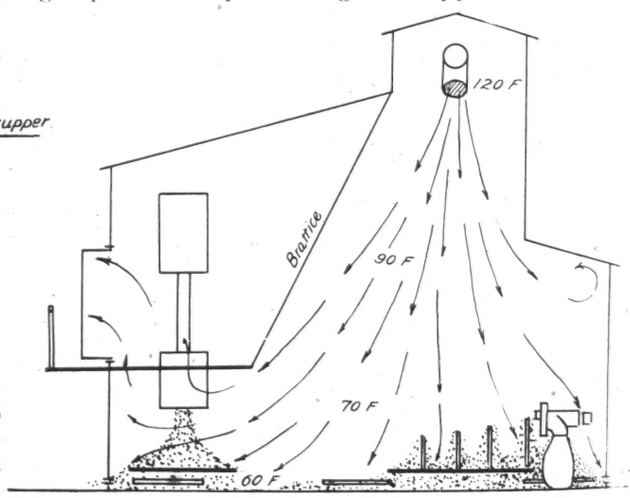


FIG. 4—THE TROUBLE ILLUSTRATED IN FIG. 3 WAS REMEDIED BY PLACING A LIGHT PARTITION OR BRATTICE AS SHOWN HERE

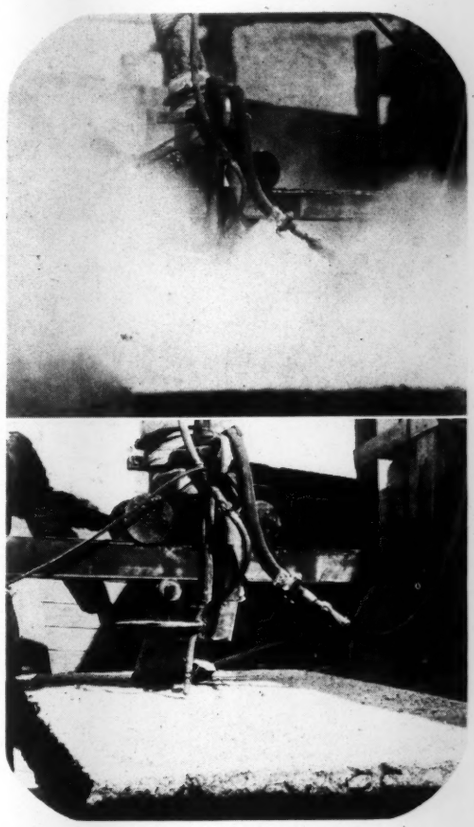
dening and tempering are typical. Mercuric oxides and vapors developed around mercury smelting and vermillion works, and the oxides of phosphorus which develop in fertilizer and phosphor bronze manufacture, are similar in behavior. All of these are very fine suspensions of microscopic dust in air and are best handled in the same manner as a gas or vapor. The second group includes a large number of ores, and some organic substances. Dinitro-benzene (*DNB*), napthalene, and most of the solid benzene ring compounds fall in this class. When dinitro-benzene was first manufactured in this country it was allowed to cool in open pans and then shoveled out by hand. Although working in the "open air" and "protected" by masks the shovelers were frequently poisoned. The trouble has been obviated in some plants by remelting under a water seal and pumping the molten material to the next process. This method can be applied to many organic solids, but some other method must be used for handling the ores of lead, mercury, antimony, chromium and manganese and their various compounds. Gas masks are effective in some cases but in others the skin will absorb the poisons, and blasts of air merely increase the amount in suspension. In this case, the best procedure is probably the use of mechanical-handling equipment, storing the materials in dust tight bins, or if these are too expensive, or if the material is not too poisonous, in storage piles at a distance from occupied buildings. The machinery can be controlled from a positively-ventilated operating chamber, and it will be found much cheaper to ventilate such a chamber than to attempt to dilute or remove the dust from the air of storage sheds.

Animal and vegetable dusts are perhaps the most difficult problem of all. They are so light that large particles settle very slowly, and in some concentration, all are explosive. Most of them are more or less irritating and disease germs may be present. Dilution does little good, since a single disease spore may cause death.

Wool, hair and leather dusts are particularly dangerous, although many otherwise apparently normal persons can not endure the dust of wood or paper. Imported wools and hides from certain portions of the world generally carry the spores of anthrax, and men touching or breathing particles of hair, hide, blood or dirt containing these spores may contract the disease. Masks and gloves are worn but many infections occur in the skin of the throat, just outside the mask and above the shirt collar, the chief victims being workers in wool, who break open and sort the bails and tanners employed in the processes previous to "liming." At present the usual custom is to open bails of wool in rooms in which there is a minimum of air movement and to trust to medical treatment if the disease develops. This is probably the safest system. Certainly high air velocities can not be permitted. Vacuum sweepers only should be used. The ultimate solution of this problem may lie in better disinfection of the hides, but to date bichloride of mercury has been used and unless this is absolutely removed subsequently, particles of hair covered with it may prove as dangerous as if infected with anthrax.

Recovery of Poison May Show Profit

The cases chosen are simply illustrative but it is believed that they represent typical problems. It will



Dusts and Fog Represent a Problem, but Great Progress Has Been Made. Above—Granite Surfacing with Dust Collecting System Not In Operation. Below—System in Operation

be noticed that in every case the problem is solved if the poison is never allowed to escape. In many cases recovery of the poison will yield a valuable by-product. The most progressive concerns today are watching these two points with the greatest care, not only because of present conditions but because of visible trends.

Classification of Objectionable Materials

Objectionable materials which may contaminate the air are numberless but they fall into four fairly distinct classifications: (1) Very poisonous gases, vapors and volatile liquids which are formed or which gain access to the open air only by infrequent and unexpected accident. (2) Similar substances, deadly or merely irritating, which are not intended to reach the atmosphere, but which through unavoidable deficiencies in technique frequently escape and the appearance of which at a given point in manufacture can be expected. (3) Vapors of solvents. (4) Dusts.

Typical accidents of the type mentioned in (1) include the bursting of autoclaves, digesters or shipping cylinders containing phosgene ($COCl_2$) gas under pressure (as occurred in Hamburg a few months ago), the escape of chlorine from cylinders after be-

ing dropped, through the failure of stevedore's hoisting sling, and as was tragically illustrated in a hospital fire some two years ago, the sudden generation of oxides of nitrogene (N_2O, NO, N_2O_4, etc.), and carbon monoxide (CO) by the combustion of low grade nitrocellulose.

The second classification includes hundreds of poisonous compounds which reach the atmosphere as the result of leakage, or intermittently when a fresh "batch" of material is being charged or removed from a digester or furnace, or which are accidentally generated due to impurities or imperfect reaction during an apparently safe process. Chlorine in bleaching plants, and carbon monoxide around gas producers, are fair examples of pollution by leakage. Caustic-laden steam escaping from alkali digesters while charging, and the vapors of benzene (C_6H_6), and its derivatives which escape when charging ports or manholes in autoclaves are opened during reactions, are typical of the intermittent type of escape. Due to the presence of arseno-pyrite in most sulphide ores, partially refined zinc and lead, and hence brass, and bearing metals, generally carry arsenic as an impurity, as does also sulphuric acid made by roasting pyrite, or as a by-product of smelting. Phosphorus is present as an impurity in iron and steel. As a result the action of "lead chamber" sulphuric acid on steel, as in pickling, produces a small quantity of arsine (AsH_3) while either "lead chamber" or "contact" acid may produce phosphene (PH_3). The amounts formed are relatively small but as 0.01 milligram of arsine is sufficient to poison a human being, even very small quantities can not be disregarded.

An example of an imperfect reaction is that afforded by the nitration of cellulose. The reaction is complicated and the states of chemical equilibrium are such that traces of practically all the oxides of nitrogen, and some unstable organic nitrous compounds are always present. Particularly where a high degree of nitration is being attempted, some of the latter break down every now and then, starting a violent decomposition in which numerous irritating and poisonous fumes are produced. Nearly every chemical plant has some substance of this class, a poisonous fume which is neither necessary nor desired but which nevertheless is formed and which causes more or less chronic contamination of the air.

It might be well to note that this type of nuisance is coming to involve more than a single plant. Sulphur dioxide is a gas which is typical of this class and gives abundant trouble in rubber and in analine manufacture. It is also formed wherever coal, petroleum or natural gas is burned.

The third class of vapors are solvents, chiefly more or less volatile organic liquids. It is perhaps more than a coincidence that most of them possess large molecules and hence are heavy and diffuse slowly. The majority are powerful reducing agents, and hence tend to act as slow poisons. Several have definite narcotic action.

Denatured ethyl alcohol is a widely used solvent. The vapor of ethyl alcohol is not noticeably irritating or poisonous, but those of the denaturing compounds may be. Benzene vapor, even in small amounts, produces grave symptoms. The effects of the vapors of methyl (wood) alcohol are not so clear, but are believed to be injurious to health. Other impurities are sometimes present. In one plant using rectified ether and alcohol as a solvent for nitrocellulose there was generally some trouble with intoxication from ether fumes, but this was seldom so severe as to require hospital treatment. In a single shift, however, from some cause, over a third of the three hundred operatives were prostrated, and the shift had to be completed with all doors and windows open and the men working in relays. The smell of ether was less noticeable than usual and it seems certain that some impurity in the solvent was responsible, the preponderance of opinion seeming to favor ethyl nitrite ($C_2H_5NO_2$), a compound always present in the recovered solvent, but generally held to very small concentrations.

It should be noted that the vapors of some of our most useful solvents (ether, benzene, carbon disulphide) are not only poisonous, but are highly inflammable. They are heavy and diffuse slowly. Hence in a room in which they are evaporating their concentration will vary at different points and there is almost certain to be an explosive mixture at *some* point. It is clear enough that they should not be permitted to escape into the air of factory buildings, but it cannot in all cases be avoided.

The last type of toxic substances are dusts. Dangerous dusts include non-metallic oxides, metals and their oxides, organic poisons and disease spores. Silica, which because of its relation to tuberculosis is regarded as among the most dangerous, is generated in sand blasting, the preparation of silex, glass-sand, and many other operations. Oxides of phosphorus form wherever white phosphorus is exposed to air as in phosphorus extracting plants, agricultural phosphate works, and rat poison factories; they are also produced in manufacturing phosphor-bronze. All are poisonous, the tetra-oxide (P_2O_4) being probably the most deadly. Oxides of arsenic form in ore-smelting plants. They are valuable and so far as possible are condensed and recovered but a certain quantity becomes suspended in the air, as also occurs wherever they are used after recovery.

Certain metallic vapors, their oxides and most of their soluble salts are poisonous or irritating. Mercury is probably the most malignant, although lead, due to its ability to accumulate in the human system, is nearly as dangerous. Furriers sometimes treat pelts with bichloride of mercury, and its use is recommended for disinfecting imported hides. The dust, however, if it remains on the hair, becomes a hazard to those subsequently handling it. Those engaged in the manufacture of felt products are particularly exposed and mercuric poisoning is to be guarded against among operatives in practically every process in felt hat manufacture.

The toxic properties of lead salts have long been known and proper precautions are generally taken. Oxides and most other salts of antimony, chromium, manganese and zinc produce serious effects. Chromium causes painful ulcers and zinc oxide is probably responsible for brass founders' ague.

Heating·Piping
and Air Conditioning

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Thermal Properties of Building Materials

By F. B. Rowley[1] and A. B. Algren[2], *MEMBERS*
Minneapolis, Minn.

This paper is the result of research conducted at the University of Minnesota in co-operation with the A. S. H. V. E. Research Laboratory

IN THE co-operative research work between the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the University of Minnesota, one of the problems has been that of analyzing and studying the laws governing heat flow through insulating materials and built-up wall constructions. The various parts of the problem have consisted in determining (1) For average walls, suitable coefficients for the surfaces for homogeneous materials used in their construction, and for air spaces, (2) By test methods the overall heat transmission coefficients for different types of wall constructions and (3) Overall heat transmission coefficients by calculation and comparing these results with those obtained by test methods.

Reports covering the details of the apparatus used and much of the test data have been published.[3]

Since these reports were published, test data have been obtained on several types of walls, including tile, brick, concrete, masonry, and some others of special design. The object of this paper is to report those data and test results which have not heretofore been published. For details of apparatus, method of procedure, etc., reference should be made to the previous papers.

Description of Walls Tested

The construction of the various walls tested by the hot box method to determine the overall coefficients is shown in detail in Figs. 1 to 9, inclusive, and a summary of test results is given in Table 1. In all cases where building paper was used in the walls, it was that known as No. 2 Building Felt, with an average weight of 44 to 55 lb per roll of 324 sq ft. In all walls where plastered surfaces or mortar joints were used, the wall was built and allowed to season a sufficient length of time before the test was made to make sure that the mortar or plaster was thoroughly dried out. In the case of concrete walls, the tests were made at various periods in the age of the wall as indicated in the discussion of the results for these tests.

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[2] Instructor in Mechanical Engineering and Assistant Director of Experimental Engineering Laboratory, University of Minnesota.

[3] Heat Transmission Research, by F. B. Rowley, F. A. Morris and A. B. Algren (A. S. H. V. E. TRANSACTIONS, Vol. 34, 1928). Overall Heat Transmission Coefficients Obtained by Tests and by Calculation, by F. B. Rowley, A. B. Algren and J. L. Blackshaw (A. S. H. V. E. TRANSACTIONS, Vol. 35, 1929). Thermal Resistance of Air Spaces, by F. B. Rowley and A. B. Algren (A. S. H. V. E. TRANSACTIONS, Vol. 35, 1929). Effects of Air Velocities on Surface Coefficients, by F. B. Rowley, A. B. Algren and J. L. Blackshaw (A. S. H. V. E. TRANSACTIONS, Vol. 36, 1930). Surface Conductances as Affected by Air Velocity, Temperature, and Character of Surface, by F. B. Rowley, A. B. Algren and J. L. Blackshaw (A. S. H. V. E. TRANSACTIONS, Vol. 36, 1930). Surface Coefficients as Affected by Direction of Wind, by F. B. Rowley and William A. Eckley (A. S. H. V. E. Section of *Heating, Piping and Air Conditioning*, October, 1931).

Discussion of Results

The coefficient of heat transmission U shown with the figure giving the detailed construction of the wall is that obtained by test for still air conditions. Table 1 shows this coefficient and, also, a transmission coefficient corrected for a wind velocity over the outside surface of the wall of 15 mph. In making this correction, an average outside surface coefficient of 1.65 was taken as that obtained by the test on a particular wall. This was the average coefficient for all tests which were made under the same conditions of air velocity over the cold surface of the wall, and was used on account of the difficulty of obtaining exact surface coefficients for several of the rough surface walls. The corrected coefficients for a wind velocity of 15 mph were taken from test data previously published for surface coefficients. In order to make them applicable to average conditions, the values obtained for parallel air flow were reduced by 15 per cent. This corresponds to the average reduction for different angles of flow as shown by the curves given in the paper, Surface Coefficients as Affected by Direction of Wind.[3]

The following formula was used in changing the coefficients of transmission from the test condition to that for a wind velocity over the outside surface of 15 mph:

$$\frac{1}{U_x} = \frac{1}{U} - \frac{1}{f_1} + \frac{1}{f_x} \qquad (1)$$

where

U = coefficient of transmission for test
U_x = coefficient of transmission for a wind velocity over the outside surface of 15 mph
f_1 = outside surface conductance for test condition
f_x = outside surface conductance for a 15-mile wind velocity

Substituting values for Wall 21, Table 1 in Formula 1:

$$\frac{1}{U_x} = \frac{1}{0.167} - \frac{1}{1.650} + \frac{1}{7.5} = 5.505$$

$$U_x = 0.181$$

Values used for surface conductances for the surfaces tested are shown in the footnote of Table 1.

Fig. 1 represents four walls which were built up, using the same surface finish on each side of an air space partition in order to determine the thermal properties of the particular combination of materials as commonly used in finishing the surfaces of frame walls. For Wall 56, both surfaces were covered with 13/16 in. fir sheathing, building paper, metal lath, and ¾-in. stucco. For Wall 57 and Wall 57B, both surfaces were covered with ⅜-in. wood lath and ⅜-in. gypsum plaster. For Wall 54, both surfaces were covered with 13/16-in. fir sheathing, building paper and 4-in. pine lap siding,

TABLE 1—SUMMARY OF RESULTS OF TESTS ON WALL CONSTRUCTION BY THE HOT BOX METHOD

Date of Test	Wall No.	Test No.	Air Temperatures, Deg Fahr			Surface Constants		Coefficient of Transmission U	
			High Side	Low Side	Mean Temp.	Inside fi	Outside fo	By Test	Corrected to a Wind Velocity of 15 mph
2/17/'28	21	431	80.5	0.	40.2	1.844	1.403	0.167	0.181
2/21/'28	21	432	80.6	0.	40.3	1.830	1.629	0.166	0.180
3/21/'28	22	445	80.05	0.05	40.1	2.007	2.188	0.318	0.375
3/22/'28	22	446	80.2	0.	40.1	1.981	2.168	0.314	0.369
3/28/'28	24	448	80.2	−0.05	40.1	1.781	1.651	0.212	0.232
3/29/'28	24	449	80.2	0.	40.1	1.789	1.847	0.214	0.234
9/1/'28	37	487	80.3	−0.15	40.07	1.675	0.859	0.101	0.106
9/27/'28	37	488	80.25	−0.35	39.95	1.819	0.914	0.107	0.113
10/2/'28	37	490	80.37	−0.23	40.07	1.834	0.720	0.099	0.104
11/23/'28	37	512	81.48	−1.0	40.24	1.855	1.291	0.106	0.111
10/30'28	42	502	80.37	0.	40.18	1.658	1.235	0.135	0.144
10/30/'28	42	502A	80.39	0.	40.19	1.678	1.465	0.138	0.147
12/4/'28	47	516	80.26	−0.03	40.11	1.667	1.448	0.365	0.427
12/27/'28	50	525	79.81	−0.57	39.62	1.680	1.567	0.499	0.640
2/5/'29	50	541	80.46	−0.29	40.08	1.662	1.624	0.499	0.640
1/29/'29	51	539	80.67	−0.38	40.14	1.690	1.548	0.357	0.425
4/23/'29	51	566	80.59	−0.37	40.11	1.714	1.591	0.354	0.422
2/1/'29	52	540	80.39	−0.32	40.03	1.808	1.571	0.412	0.504
4/18/'29	52	565	80.66	−0.57	40.04	1.841	1.619	0.401	0.487
1/10/'29	54	532	80.33	−0.51	39.91	1.625	1.524	0.171	0.183
4/30/'29	54	568	80.79	−0.98	39.90	1.716	1.526	0.168	0.180
1/25/'29	55	538	80.81	−0.48	40.17	1.646	1.668	0.588	0.792
4/26/'29	55	567	80.90	−1.07	39.91	1.646	1.625	0.572	0.762
11/5/'29	55	583	80.27	−0.02	40.12	1.665	1.605	0.579	0.776
9/23/'30	55	597	79.5	0.40	39.95	2.615	1.721	0.582	0.780
2/7/'29	56	542	79.79	−0.04	39.88	1.768	1.486	0.227	0.254
2/8/'29	56	543	79.81	0.0	39.90	1.777	1.493	0.227	0.254
2/14/'29	57	544	79.73	−0.16	39.78	1.700	1.585	0.331	0.381
2/15/'29	57	545	79.74	0.05	39.89	1.716	1.677	0.335	0.387
5/10/ 29	57B	573	79.47	−0.33	39.57	1.649	1.511	0.330	0.380
6/18/'29	59	575	80.94	−0.90	40.02	1.747	1.505	0.280	0.319
6/20/'29	60	576	81.24	−1.08	40.08	1.831	1.474	0.266	0.301
6/22/'29	61	577	79.93	0.02	39.98	1.602	1.561	0.270	0.306
7/9/'29	61A	582	79.98	0.13	40.05	1.777	1.480	0.265	0.300
6/27/'29	62	579	79.92	0.01	39.96	1.815	1.884	0.205	0.226
7/2/'29	63	580	79.93	0.22	40.07	1.726	1.800	0.343	0.403
6/25/'29	64	578	79.94	0.14	40.04	1.708	1.318	0.265	0.299
7/6/'29	65	581	79.99	0.13	40.06	1.733	1.528	0.255	0.290
5/24/'30	66	589	80.30	−0.05	40.12	1.711	1.627	0.310	0.360
5/27/'30	67	590	80.40	−0.15	40.12	1.732	1.654	0.320	0.372
10/2/'30	68	599	79.81	0.05	39.93	1.803	2.247	0.590	0.795
9/26/'30	69	598	79.89	0.09	39.99	1.924	1.655	0.585	0.785
6/10/'30	70	594	80.09	0.10	40.09	1.544	1.981	0.358	0.425
10/9/'30	70	601	79.80	0.20	40.00	1.618	1.618	0.353	0.418
6/13/'30	71	595	80.10	0.15	40.12	1.594	1.605	0.460	0.576
10/7/'30	71	600	79.85	0.10	39.97	1.662	1.559	0.457	0.571
6/6/'30	72	593	80.07	0.0	40.04	1.571	1.575	0.436	0.540
6/3/'30	73	592	79.85	0.35	40.10	1.632	1.648	0.408	0.497
6/18/'30	74	596	80.08	0.33	40.20	1.604	1.895	0.413	0.504
1/20/'31	75	627	79.98	0.13	40.05	1.623	1.477	0.540	0.707
1/14/'31	76	626	79.90	0.04	39.97	1.622	1.529	0.553	0.729
10/15/'30	78	602	79.82	0.52	40.17	1.954	1.616	0.691	.....
2/5/'31	78B	631	80.22	−0.43	39.89	1.246	0.923	0.460	.....
10/27/'30	79	606	78.89	−0.04	39.42	1.761	1.588	0.264	.....
10/30/30	79A	608	80.16	−0.08	40.04	1.280	1.164	0.169	.....
11/10/'30	79B	610	80.12	0.06	40.09	1.230	1.467	0.175	.....
11/18/'30	79B	611	79.97	0.02	39.99	1.252	1.291	0.171	.....
10/28/'30	80	607	79.87	−0.27	39.80	1.746	1.407	0.257	.....
5/26/'31	80A	661	81.00	2.08	41.54	0.814	1.757	0.130	.....
1/6/'31	81	624	79.06	−0.20	39.43	1.671	1.542	0.344	0.405
1/8/'31	82	625	80.02	0.	40.01	1.701	1.429	0.379	0.454
11/25/'30	83	613	79.60	0.07	39.83	1.726	1.623	0.407	0.495
4/13/'31	90	650	80.38	−0.17	40.10	1.661	1.533	0.344	0.405
4/16/'31	91	651	80.27	−0.01	40.13	1.719	1.532	0.354	0.418
4/20/'31	92	652	80.31	0.19	40.25	1.760	1.575	0.337	0.396

(Note 1) Average surface conductance (f_o) for walls as tested = 1.650.
(Note 2) Surface conductance (f_o) for pine surface for outside wind exposure of 15 mph = 4.75.
(Note 3) Surface conductance (f_o) for stucco surface for outside wind exposure of 15 mph = 7.50.
(Note 4) Surface conductance (f_o) for brick surface for outside wind exposure of 15 mph = 6.10.
(Note 5) Surface conductance (f_o) for concrete, tile, cinder block, and rubble stone surfaces for outside wind exposure of 15 mph = 5.78.
(Note 6) Surface conductance (f_o) for plaster surface for outside wind exposure of 15 mph = 4.68.

and for Wall 47 both surfaces were covered with ⅜-in. gypsum board papered on both surfaces. It will be noted that Walls 57 and 57B are of the same construction and tested under the same conditions. In several cases, duplicate walls were made in order to determine the differences to be expected in construction. In all such cases, the differences in test values were very small, although it should be remembered that in practice very great differences in workmanship are possible. The coefficients for these walls are given at a mean temperature of 40 F, although they were actually obtained for mean temperatures varying from 30 F to 110 F. The results for these tests are shown by the curves of Fig. 10.

Clay Tile Walls, Test Results

Figs. 2, 3, 4, and 5 show a group of 15 clay tile walls. Fourteen of these walls are 8 in. thick, are built with tile of different cell structure, and are treated differently as to joints and surface finish. The range in values of the conductivity coefficient U for the unfinished walls is from 0.354 for Wall 91, Fig. 5, to 0.265 for Wall 64, Fig. 3.

Wall 63, Fig. 3, and Wall 91, Fig. 5, are built of a common type of three-cell tile, the construction being similar, although the tiles were obtained from different manufacturers. The coefficients for these walls are 0.343 and 0.354, respectively, which may be taken as reasonable averages for this type of construction.

In Walls 92 and 67, the air cells have been broken up in such a manner as to give substantially four cells

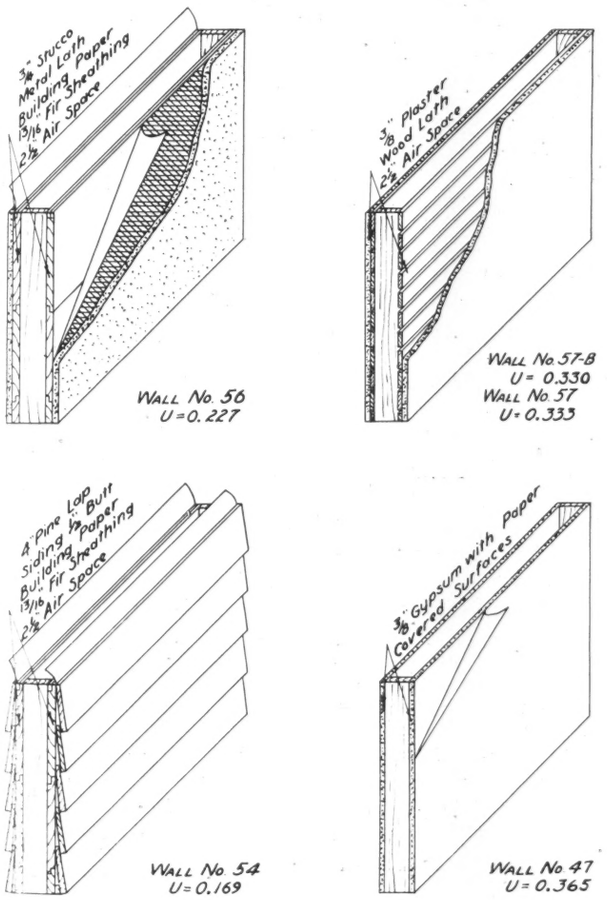


Fig. 1—Sectional Views of Test Walls Nos. 47, 54, 56, 57, 57-B

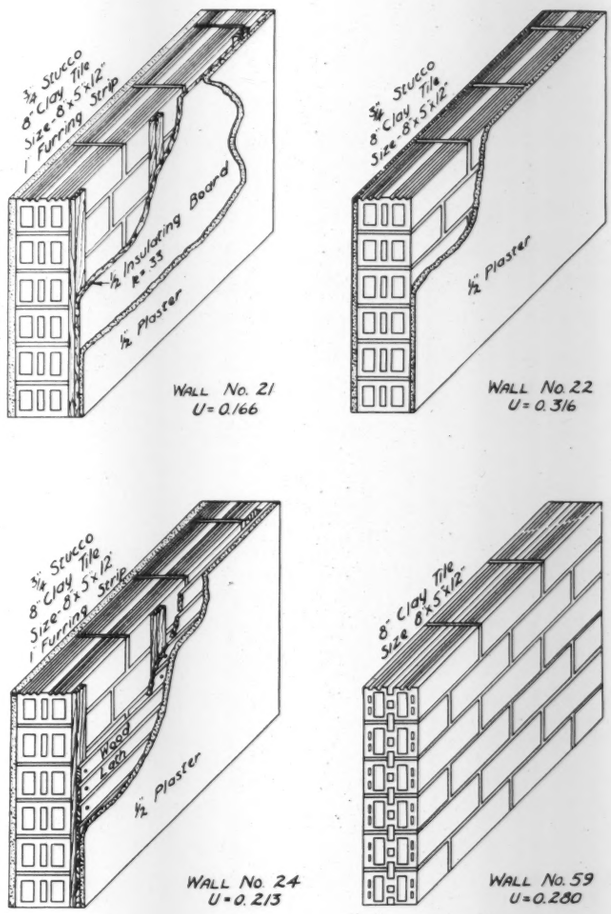
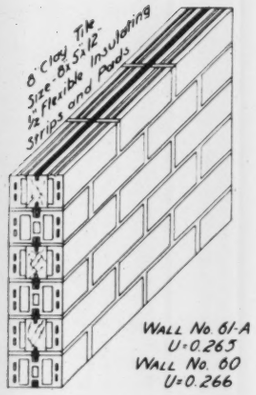


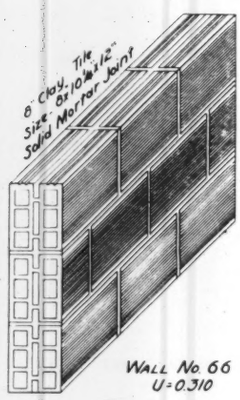
Fig. 2—Sectional Views of Test Walls Nos. 21, 22, 24, 59

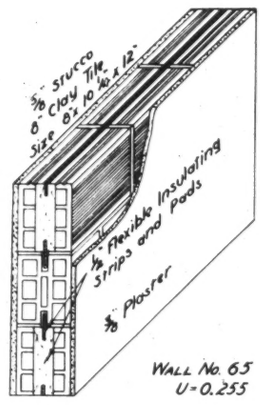
for Wall 92 and five cells for Wall 67. The coefficients of conductivity are 0.337 and 0.320, respectively, indicating that, as the air cells are broken up into greater numbers, the conductivity of the finished wall is decreased.

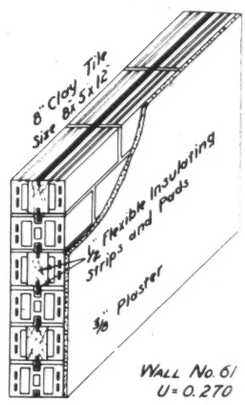
In each of the four walls, No. 63, 91, 92, and 67, there is a direct path for the flow of heat through the top and bottom surfaces of the individual tile. In other words, there is a direct line of low heat-resisting material through which heat may flow from the hot to the cold surface of the wall. As a direct contrast to this, consider Wall 64 in which the air spaces are staggered, giving a longer path through the material for the flow of heat from surface to surface. In the construction of this wall, care was exercised to keep the center opening free from mortar. The coefficient U is 0.265, which is a material reduction over the other type.

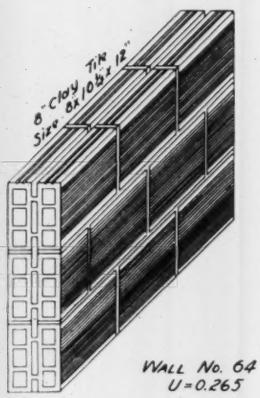
Wall 66 was built of the same tile as Wall 64, but, in this case, the joints were filled solid with mortar. The coefficient was increased to 0.31 as compared with 0.265 when the joints were not filled. Wall 65 was built of the same tile as Wall 64, but, for Wall 65, ½-in. insulating strips were placed horizontally in the open air spaces at the joints, and insulating pads were placed at the end of each tile as shown in Fig. 4. These insulating pads and strips gave slightly better insulation than the air space and prevented any mortar from getting into the joints, and, as shown from the results, reduced the coefficient to 0.225 as compared with 0.265











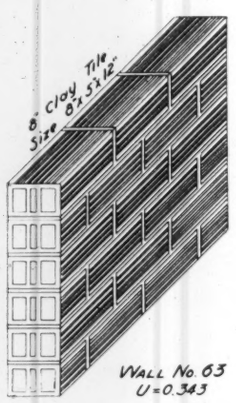
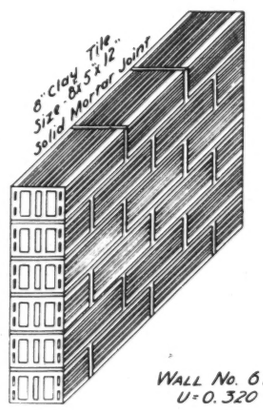


Fig. 3—Sectional Views of Test Walls Nos. 60, 61-A, 63, 64, 66



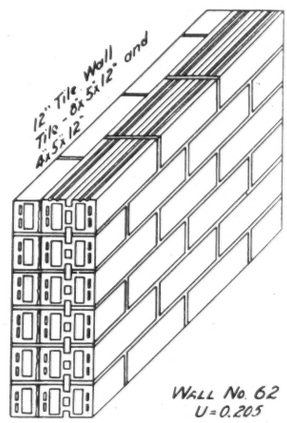


Fig. 4—Sectional Views of Test Walls Nos. 61, 62, 65, 67

without the strips. This reduction, however, may have been partly due to the surface finish on the wall.

Walls 59, 60, and 61A were built of the same tile, the difference being that Walls 60 and 61A have insulating strips placed in the joints, filling the central air space between the tile, and, also, insulating pads at the end of the tile. In these walls, the insulating strips reduced the coefficient from 0.28 to 0.265. Wall 61 was of the same construction as Walls 60 and 61A, with the exception that the ⅜-in. plaster was applied to the inner surface of Wall 61. The coefficient for the plastered wall was 0.27 as compared with 0.265 for the wall without the plaster. This increase may have been due to some slight difference in surface coefficients or to a difference in construction which can always be expected in walls of this character. Wall 62 was built of the same tile as Wall 59, the difference being that it was built 12 in. wide, using one and one-half thicknesses of the tile. If for these walls the surface coefficients are deducted, it is found that the conductances are proportional to the thicknesses.

In general, it may be said that the efficiency of a tile wall is increased by breaking up the air spaces and by eliminating any direct paths or tile connections between the two surfaces of the wall. The greatest improvement seems to be possible by breaking up the direct path for heat flow.

The effect of different surface finishes on the tile walls is shown by Walls 21, 22, and 24 of Fig. 2. In these walls the same tile was used, the exterior finish in each case being ¾ in. stucco and the interior finish being ½ in. plaster applied direct to the tile for Wall 22; applied to wood lath furred out for Wall 24, and applied to ½-in. insulating board furred out for Wall 21. Wood lath on 1-in. furring strips reduces the coefficient from 0.316 to 0.213, while ½-in. insulating board, with a coefficient of conductivity k of 0.33, on 1-in. furring strips reduces the coefficient to 0.167.

Concrete Walls, Test Results

Concrete walls, Nos. 55, 68, and 69, Fig. 8, were of monolithic construction, Nos. 71 and 72, Fig. 7, were built of 8-in. three-cell concrete blocks, and Nos. 73 and 74, Fig. 7, were built of 12-in. three-cell concrete blocks. Referring to the first three, No. 55 was built of a 1:2:4 mix and Nos. 68 and 69 were built of a 1:2 ½:4 mix. Wall 68 was mixed with water to give a 6-in. slump, and Wall 69 was mixed to give a 3-in. slump. In all cases, No. 4 sand was used, that is sand of which 95 per cent passed through a No. 4 sieve, and the gravel was graded from 1½ in. to ¼ in. The results of these three tests were so close that it would indicate that the slump tests had nothing to do with the thermal conductivity of the material.

In concrete walls, it is some time before the moisture is thoroughly eliminated and the conductivity coefficient becomes uniform. In order to get the effect of time on the conductivity of the concrete, tests were made at different ages, as shown in Table 2. The results of these tests indicate that the coefficient of conductivity k for concrete as tested is about 11.5 after the concrete

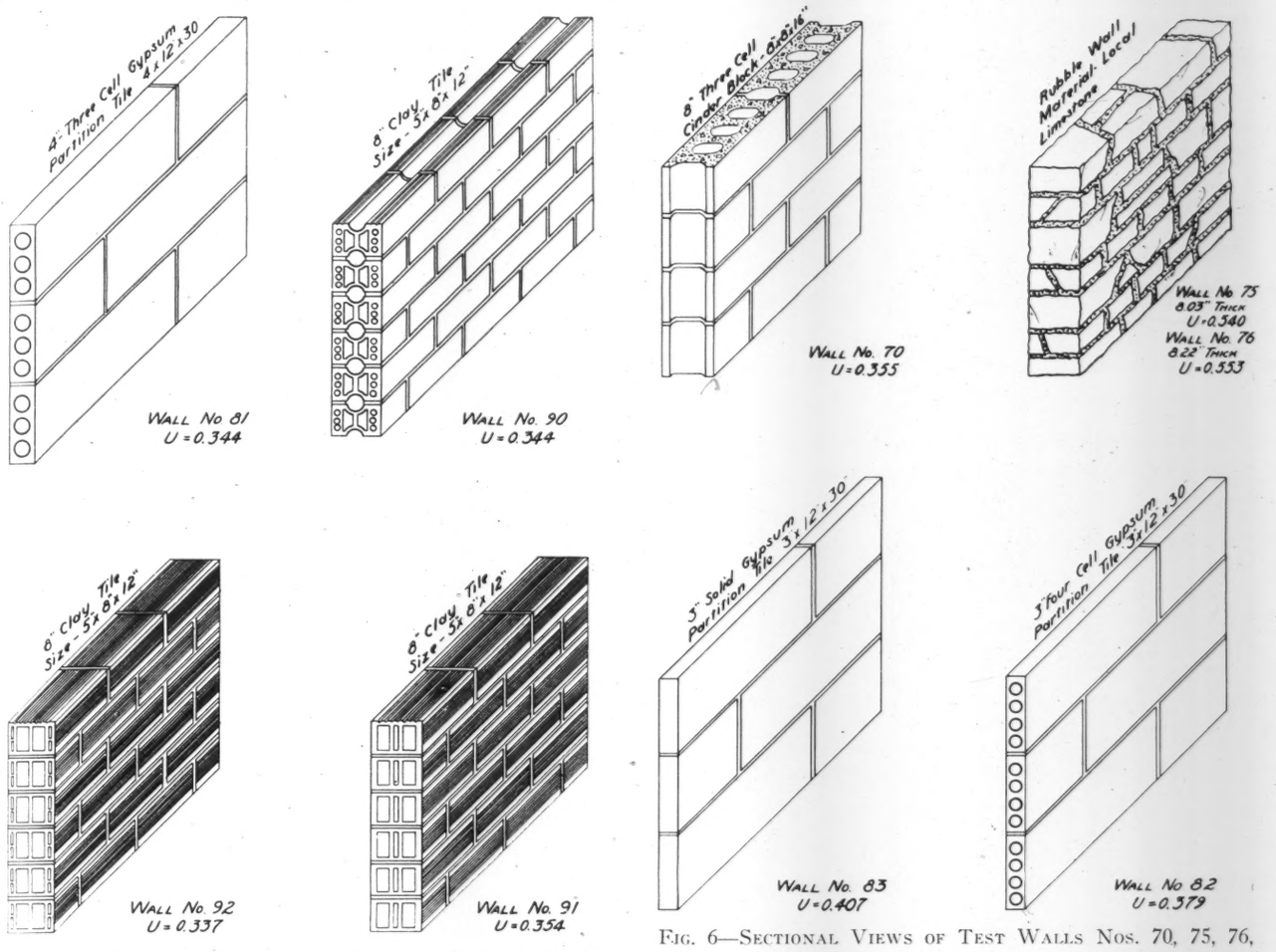

4" Three Cell Gypsum Partition Tile 4 x 12 x 30
Wall No 81
U = 0.344
8" Clay Tile Size - 5" x 8" x 12"
Wall No. 90
U = 0.344
8" Three Cell Cinder Block - Gable
Wall No. 70
U = 0.355
Rubble Wall Material - Local Limestone
Wall No 75
8.03" Thick
U = 0.340
Wall No. 76
8.22" Thick
U = 0.353
8" Clay Tile Size - 5" x 8" x 12"
Wall No. 92
U = 0.337
8" Clay Tile Size - 5" x 8" x 12"
Wall No. 91
U = 0.354
3" Solid Gypsum Tile 3 x 12 x 30
Wall No. 83
U = 0.407
3" Four Cell Gypsum Partition Tile 3 x 12 x 30
Wall No 82
U = 0.379

Fig. 5—Sectional Views of Test Walls Nos. 81, 90, 91, 92

Fig. 6—Sectional Views of Test Walls Nos. 70, 75, 76, 82, 83

has been thoroughly cured. This coefficient will naturally be somewhat different for different aggregates and mixes.

The two 8-in. concrete block walls, Nos. 71 and 72, were built of blocks which were of the same dimensions but which were purchased from different manufacturers. The variation in these test results from 0.436 to 0.458 may be accounted for partly by the possible difference in the amount of mortar placed in the joints, partly by a difference in the aggregate used, and, possibly, to experimental differences. The 12-in. concrete block walls Nos. 74 and 73 were likewise built from blocks of the same dimensions but purchased from different manufacturers. In this case, the test results, 0.408 and 0.413, show a very close agreement.

Wall 70, Fig. 6, was built from 8-in. three-cell cinder-concrete blocks purchased on the open market. In these blocks, the aggregate was made completely of cinders, and the density was found to be 105 lb per cubic foot. There is naturally a variation in cinders, and any one test cannot be considered as a standard. However, the coefficient of 0.355 as compared with the coefficient of 0.447 for walls of the same type of concrete block indicates a considerable reduction in heat transmission for cinder-concrete.

Table 2—Effect of Age on Conductivity of Concrete

Wall No.	Age of Wall	Thermal Conductivity k
55	1 month 5 days	12.3
55	4 months 6 days	11.2
55	11 months 15 days	11.6
55	22 months 3 days	11.8
55	36 months	10.7
68	10 months	12.4
68	26 months 21 days	11.6
69	9 months 17 days	12.1

Brick Walls, Test Results

In Figs. 7 and 8, five brick walls are shown which are constructed either entirely of brick or of brick in combination with other materials. Walls 50 and 51 are both constructed of common yellow bricks, 8 in. x 3¾ in. x 2½ in. in dimension. Wall 50 is a single row and Wall 51 a double row of brick. If for these walls the inside and outside surface coefficients be taken as 1.65, the thermal conductivity $k = 5.0$.

Wall 52 is an 8-in. wall composed of one layer of 4-in. common yellow brick and one layer of pressed face brick. The coefficient U for this wall is 0.406 as compared with 0.356 for the same thickness of wall built entirely of common brick, indicating that the surface brick has a much higher coefficient of conductivity than the common yellow clay brick. Wall 37 shows an insulated frame wall with a brick veneer finish, and Wall 42 shows an 8-in. brick wall with insulating material, furring lath, and plaster on the inside.

Gypsum Partition Tile Walls, Test Results

Wall 81 of Fig. 5 and Walls 82 and 83 of Fig. 6 were built of different thicknesses of gypsum partition tile as shown. By comparing the results for Walls 82 and 83, it is found that the cylindrical openings through the tile reduce the conductivity coefficient for the 3-in. wall from 0.407 to 0.379, or, in other words, these openings introduce a heat resistance into the wall equal to 0.18. If for Wall 83 the average inside and outside surface coefficients are taken to be 1.65, the thermal conductivity per inch of material is found to be 2.5.

Rubble Walls, Test Results

Walls 75 and 76, Fig. 6, were built of limestone and were approximately 8 in. thick. The conductivities of these walls were 0.54 and 0.553, respectively, a variation well within experimental limits for walls of this type. If an average overall coefficient is used and the surface coefficients are taken as 1.65 for both inside and outside surfaces, the thermal conductivity k for the wall is found to be 12.5, or slightly higher than that found for concrete walls. It is probable, however, that the surface coefficients may be somewhat higher than the average of 1.65, due to the uneven character of the surfaces.

Effect of Mean Temperature on Heat Transmission Through Built-up Wall Sections

In built-up wall sections and insulating materials, there is a variation in the heat transmission coefficients with variations in mean temperatures. The coefficient is increased as the mean temperature through the test section is increased, and, for practical purposes, this increase is a straight line relation.

Fig. 10 shows a set of curves giving the test results for walls at mean temperatures varying from 30 F to 110 F. With the exception of Wall 80A, the surfaces of which were covered with aluminum foil, the variation is substantially the same for all walls. This variation is in general somewhat greater than that found for homogeneous materials, probably due to the more definite air spaces in the construction of the walls.

Surface Effect on Heat Transmission

Heat is transmitted from the surface of a material by convection, conduction, and radiation. The amount given off by convection is governed by the roughness of the surface and wind velocity. The effect of wind velocity on average building surfaces has been shown in the results previously published. The radiation coefficient is substantially the same for such materials as paper, wood fiber materials, plaster, concrete surfaces, glass, and, in fact, the majority of building materials. Certain metal surfaces, however, have a greatly reduced radiation coefficient. In order to show the effect of a few of these surfaces, several walls were constructed of 3/8-in. gypsum board, part of them with air spaces and part of them without air spaces. The surfaces of the boards were covered with paper, aluminum bronze,

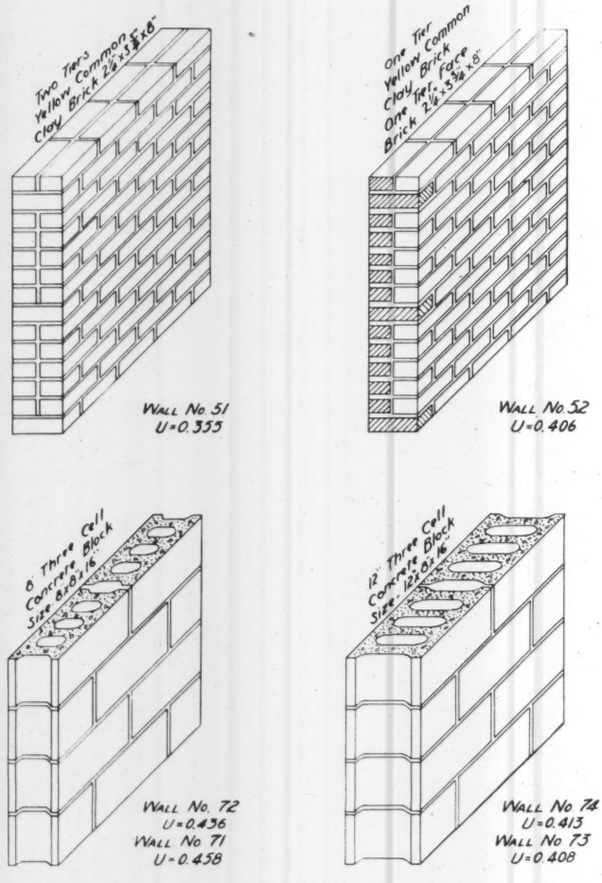

Two Tiers Yellow Common Clay Brick 2⅛ x 3⅝ x 8"
WALL No. 51 U=0.355
One Tier Yellow Common Clay Brick
One Tier Face Brick 2⅛ x 3⅝ x 8"
WALL No. 52 U=0.406
8" Three Cell Concrete Block Size 8x8x16
WALL No. 72 U=0.436
WALL No. 71 U=0.458
12" Three Cell Concrete Block Size 12x8x16
WALL No. 74 U=0.413
WALL No. 73 U=0.408

FIG. 7—SECTIONAL VIEWS OF TEST WALLS NOS. 51, 52, 71, 72, 73, 74

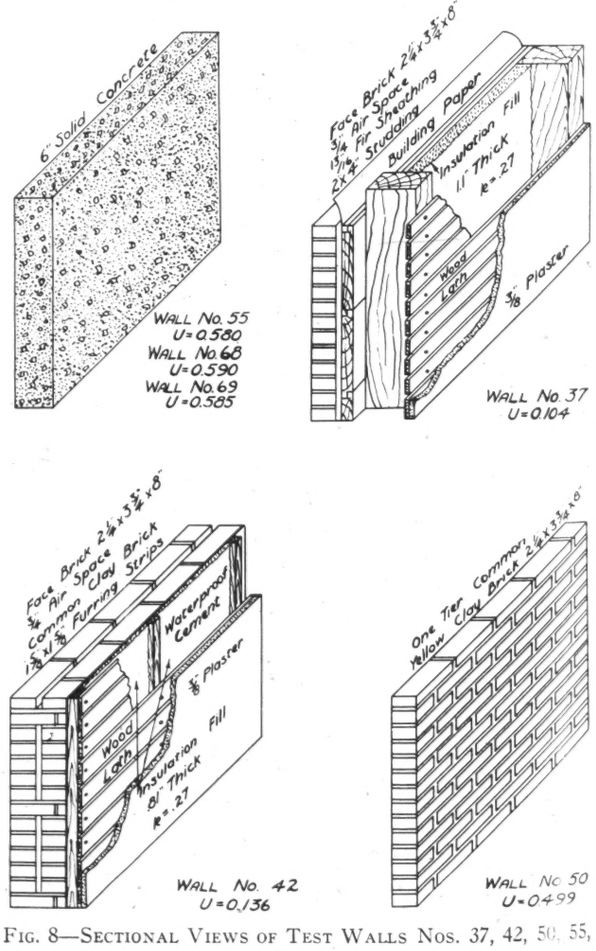


FIG. 8—SECTIONAL VIEWS OF TEST WALLS NOS. 37, 42, 50, 55, 68, 69

gold bronze, and aluminum foil. The details of the construction of the several walls are shown in Fig. 9.

These walls were tested by the hot box method, the results of the tests being given in Table 1 and in Table 2. Referring to Table 3, the coefficients of heat transmission U are the test results as determined at a mean temperature of 40 F. The over-all resistance was taken as the reciprocal of the coefficient U. The surface resistances were calculated by taking an average surface coefficient for the paper covered wall of 1.65. This applied directly to Walls 78, 79, and 80. The surface resistance for Wall 78B was taken as the difference between the over-all heat resistance and the resistance of the material in the wall. The surface resistances for Walls 79A and 79B were taken from test data and the surface resistances for Wall 80A were taken the same as those for Wall 78B, since the surface covering was of the same material. The resistance of the gypsum board from which the walls were made was taken from test data for Wall 78, using three times this value for those walls in which three sheets of material were used.

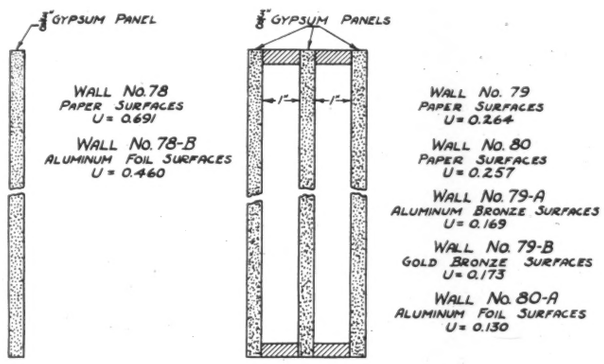


FIG. 9—WALLS CONSTRUCTED TO SHOW THE EFFECT OF SURFACE FINISH ON HEAT TRANSMISSION

TABLE 3—COMPARATIVE HEAT RESISTANCES FOR SURFACES AND AIR SPACES LINED WITH PAPER, BRONZE PAINT, AND ALUMINUM FOIL

WALL NO.	COEFFICIENT OF TRANSMISSION U	HEAT RESISTANCE $\frac{1}{U}$	SURFACE RESISTANCES $\frac{1}{f_o}+\frac{1}{f_i}$ CALCULATED	HEAT RESISTANCE OF MATERIAL	RESISTANCE OF 1-IN. AIR SPACE CALCULATED
78	0.691	1.446	1.212	0.234	.....
78B	0.460	2.172	1.938	0.234	.....
79	0.264	3.780	1.212	0.702	0.93
80	0.257	3.890	1.212	0.702	0.93
79A	0.169	5.920	1.639	0.702	1.79
79B	0.171	5.840	1.573	0.702	1.78
80A	0.130	7.690	1.938	0.702	2.52

The heat resistance of the air spaces shown in the last column of Table 3 was calculated from the over-all resistance, the surface resistances, and the resistance of the solid material of the wall. The resistance for Walls 79 and 80, in which the surfaces were lined with paper, checked almost exactly with the resistance as previously determined for 1-in. air spaces lined with fibrous material. In the previous work, the resistance for 1 in. air space at a mean temperature of 40 F was found to be 0.90, whereas, in these tests, it was found to be 0.93. This would indicate that the method used in calculating the air space resistances gives reasonably accurate results. The resistances for the various parts of Walls 79A and 79B, in which the surfaces are covered with aluminum bronze and gold bronze, respectively, are substantially the same. The resistance of the air space bounded by aluminum foil is shown as 2.52, or nearly three times that of the air space bounded by paper. These tests showed decidedly the importance of radiant heat as a factor in surface transmission even at the relatively low temperatures as used in building construction.

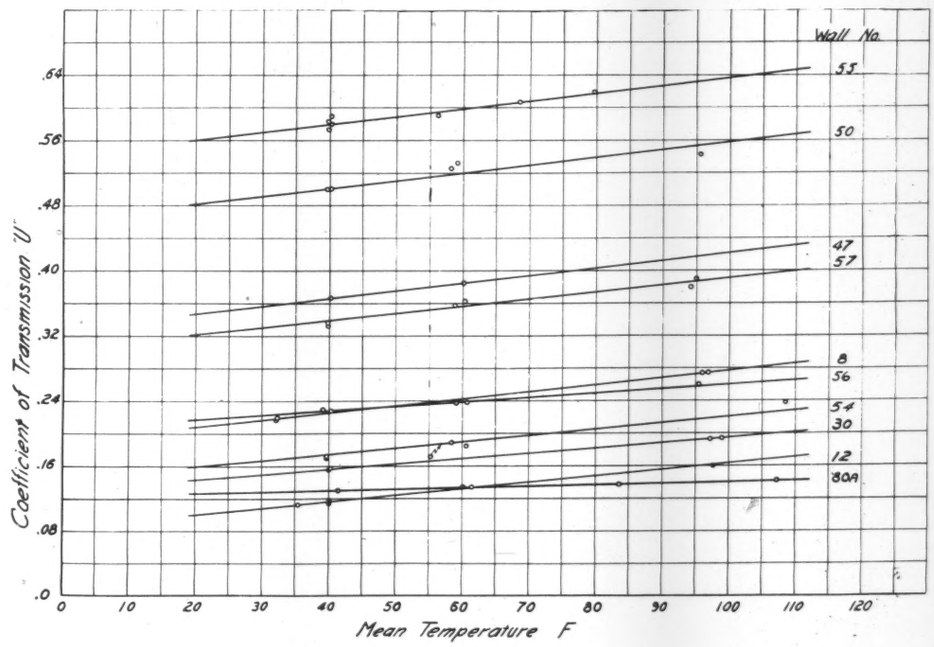


FIG. 10—RELATION BETWEEN COEFFICIENT OF HEAT TRANSMISSION U AND MEAN TEMPERATURE FOR VARIOUS TYPES OF WALL CONSTRUCTION

Velocity Characteristics of Hoods Under Suction

By J. M. Dallavalle[1], Cleveland, Ohio
NON-MEMBER

EVERY hood under suction creates a movement of air which is directed into its opening. The intensity of this movement is a maximum at the opening and diminishes swiftly with the distance from it. In any plane in this region of influence, curves may be drawn which represent constant values of the air velocity. A series of such curves representing a velocity distribution are commonly called lines of velocity potential or contours of equal velocity. If a set of curves be traced so as to be perpendicular at every point of intersection with these contours, they are designated as stream lines, or lines whose tangent at any point gives the direction of flow. Between two such curves the volume of flow is constant. Thus, in Fig. 1 indicating a diametrical plane in the region of influence of a duct end under suction, the curves *A, B, C,* etc. are equal velocity contours having the values *A, B, C,* etc., and the curves *0, 1, 2, 3,* indicate the direction of flow along a succession of points lying on them. Moreover, as has been stated, the flow across a section *pq* is equal to the flow across *mn, jk,* etc.

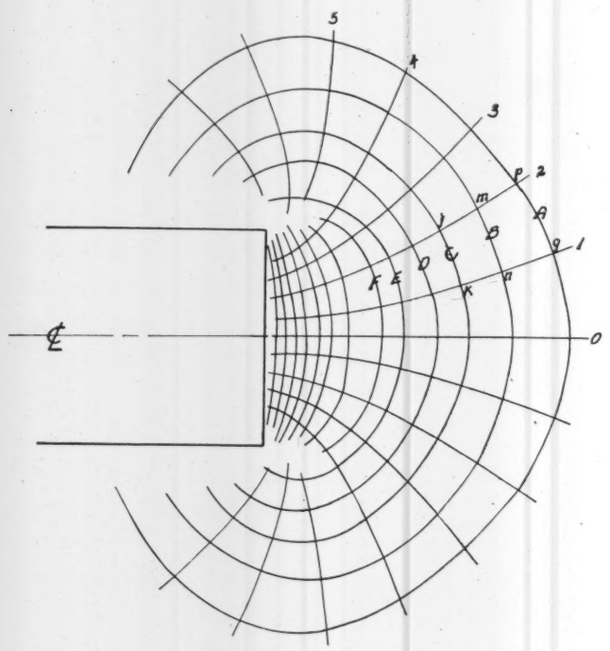


FIG. 1—VELOCITY CONTOURS AND STREAM LINES FOR A CIRCULAR DUCT END

From the geometric symmetry of a circular opening, it is easily seen that the velocity conditions existing in Fig. 1 are the same through any other diametrical plane. Consequently, the rotation of the plane about the axis will generate surfaces of equal velocity and tubular sheets of flow. Thus, the velocity and stream line distributions in a single radial plane of a circular opening represents the conditions existing throughout the sphere of influence. Further, it can be shown [2] that whatever the size of the duct end, or whatever the volume of flow, the velocity contours and the stream lines are always of the same general form. These facts which have been experimentally determined, may be extended to all hoods and condensed into the following theorem: *The positions of the velocity contours for any hood when the contours are expressed in terms of the velocity at the hood opening are purely functions of the shape of the hood; the contours are identical for similar hood shapes when such hoods are reduced to the same basis of comparison.* For example, if the velocity 4 in. outward along the axis of an 8-in. diameter duct end is 26 per cent of the velocity in the plane of the opening, the same value must occur for a 12-in. diameter duct end at a distance of 6 in. In other words, if the diameters of each opening be divided into a stated number of parts and if each field of influence be divided in corresponding units, the contours will be identical.

An extension of these important facts to rectangular hoods appears difficult at first since velocity distributions will vary in every radial plane drawn through a whole quadrant. However, in corresponding planes, this must necessarily hold true. In such cases, it is convenient to consider the distributions in two center planes at right angles to each other. These planes are designated according to the side to which they are perpendicular. In square openings, of course, the velocity distributions in two such planes must be the same.

Effect of Shape on the Distribution of Velocity Contours

It may reasonably be supposed that the amount and the degree of flaring of a hood has considerable effect on the distribution of the velocity contours. If, however, it is assumed that the distributions of flow across two *openings* of the same size and shape are similar, the velocity contours are substantially the same, although the degree of flare in each differs. The main portions of the sphere of influence which are affected lie behind the edge of the opening, the boundary surface of the flared portion being the chief variable. The velocity contour distribution, therefore, may be said to be dependent upon the shape of the opening only, provided the distribution of flow across it does not vary greatly

[1] Department of Public Welfare, City of Cleveland, Ohio.

[2] Studies in the Design of Local Exhaust Hoods, by Dallavalle and Hatch. (A paper presented at the Sixth Annual Wood-Industries Meeting, *American Society of Mechanical Engineers,* October 15, 16, 19[illegible])

with the degree of flare. As a matter of experiment, it has been found that over a very wide range the degree of flare alters the distribution of flow across an opening only slightly.[2] Hence, a 5-in. by 10-in. opening with a 12-in. flare to a 3-in. diameter duct gives the same contour distribution forward of an opening as one with an 8-in. flare (say) to a 5-in. diameter duct. In fact, were the opening but the end of a 5-in. by 10-in. duct, the velocity contour distribution would differ only slightly. Since, as a rule, most hoods are gradually flared in order to reduce entrance losses, it is practical when dealing with contour distributions, to express the overall

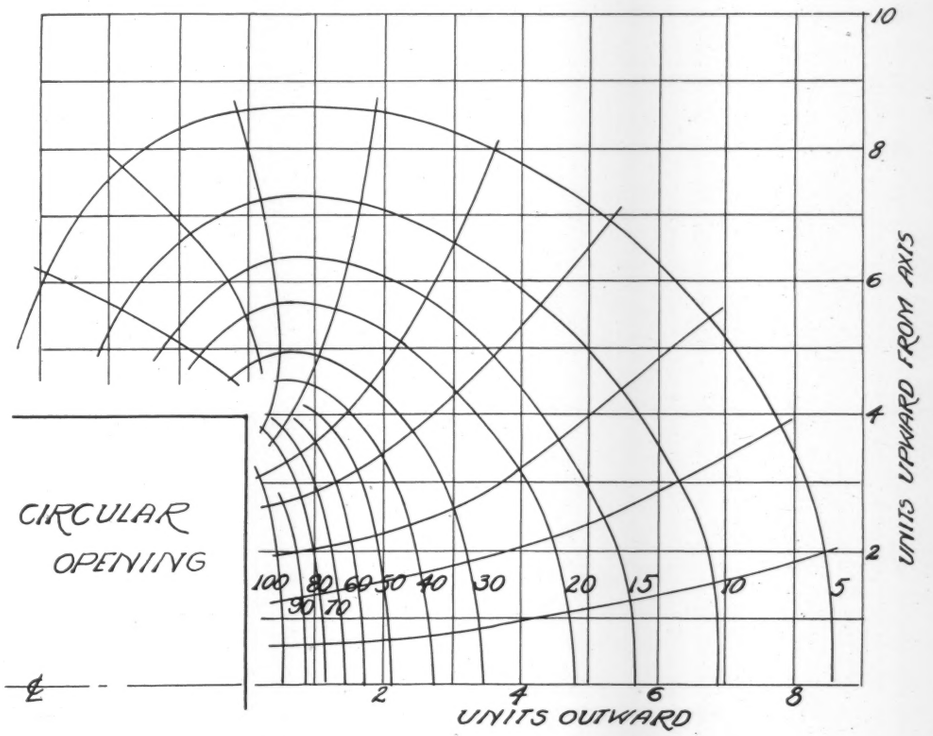


FIG. 2—VELOCITY CONTOURS AND STREAM LINES IN A RADIAL PLANE OF A CIRCULAR OPENING. CONTOURS ARE EXPRESSED AS PERCENTAGES OF THE AVERAGE VELOCITY IN THE PLANE OF THE OPENING

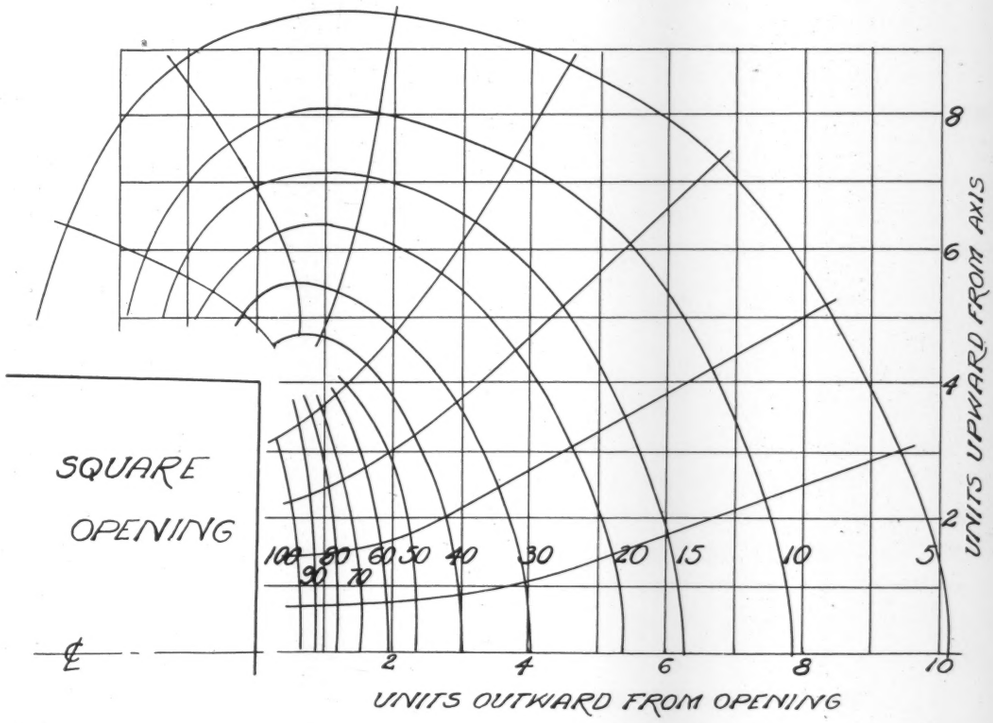


FIG. 3—VELOCITY CONTOURS AND STREAM LINES IN A RADIAL PLANE PERPENDICULAR TO ONE OF THE SIDES OF A SQUARE OPENING

shape of the hood in terms of the shape of its opening. In the case of rectangular openings, the shape will be referred to in terms of the ratio of the short side to the long side, a 5-in. by 10-in. opening, for example, having a ratio of sides equal to ½, and is so designated.

Discussion

The velocity contours and stream lines for various types of hood openings are shown in Figs. 2 to 7 in the manner already discussed. Thus, provided the region of influence for all round openings is mapped in the coordinate units corresponding to Fig. 2, the velocity contours will all be identical and will be expressed in per cent of the average velocity in the plane of the opening. The same is true for the various shaped rectangular hoods where the short side of each is divided into eight units, and the long side in the same units in proportion to its length. An opening, therefore, with a ratio of sides of 3 to 4 will have $\frac{8 \times 4}{3} = 10\,2/3$ units on the long side.

An example will illustrate the application of the contour lines of Figs. 2 to 7. Suppose it is desired to find the speed and direction of the air movement at a point 4 in. upward and 5 in. outward in the radial plane perpendicular to the short side of a 4-in. by 12-in. hood handling 1,200 cfm. The ratio of sides is 1/3 and expressing the coordinates of the point on the basis that there are 8 units of length on the short side the coordinates of the point in question are 8 units upward of the axis and 10 units outward, as shown by the circle

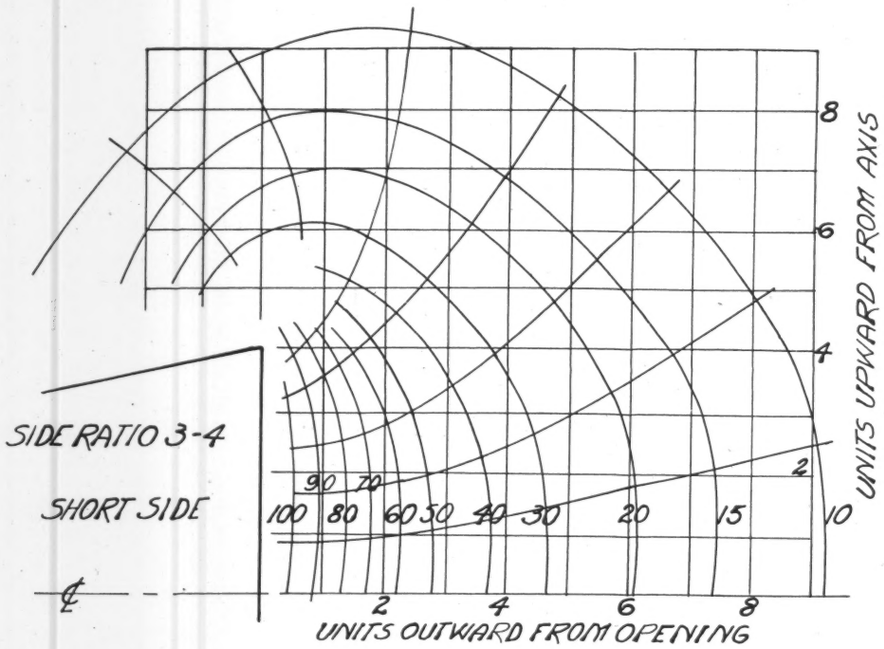


FIG. 4*a*—VELOCITY CONTOURS AND STREAM LINES FOR A RECTANGULAR OPENING WHOSE RATIO OF SIDES IS 3 TO 4—CONTOURS AND STREAM LINES IN RADIAL PLANE PERPENDICULAR TO LONG SIDE OF OPENING

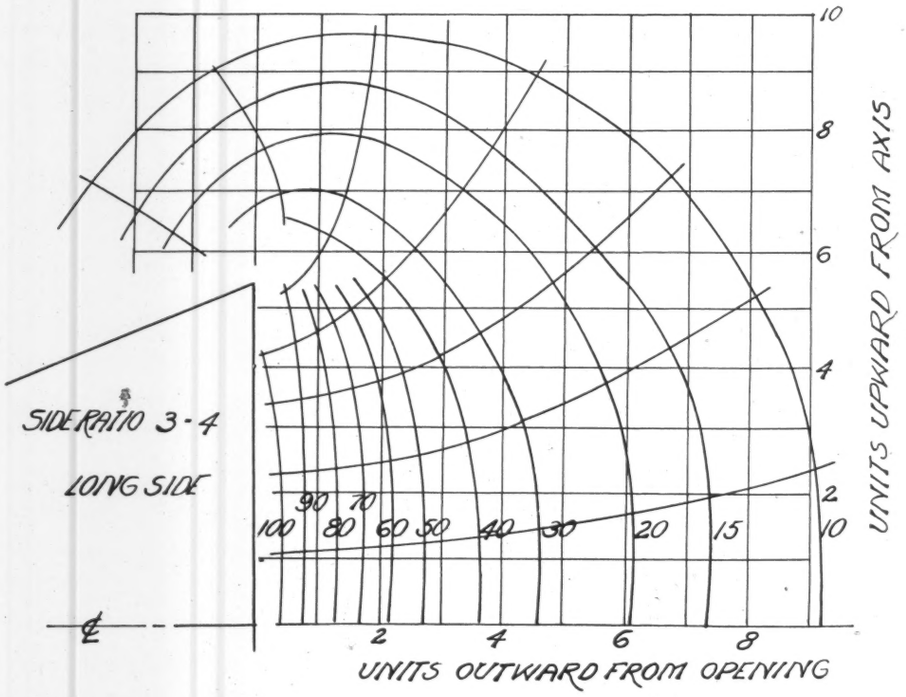


FIG. 4*b*—VELOCITY CONTOURS AND STREAM LINES FOR A RECTANGULAR OPENING WHOSE RATIO OF SIDES IS 3 TO 4—CONTOURS AND STREAM LINES IN RADIAL PLANE PERPENDICULAR TO SHORT SIDE OF OPENING

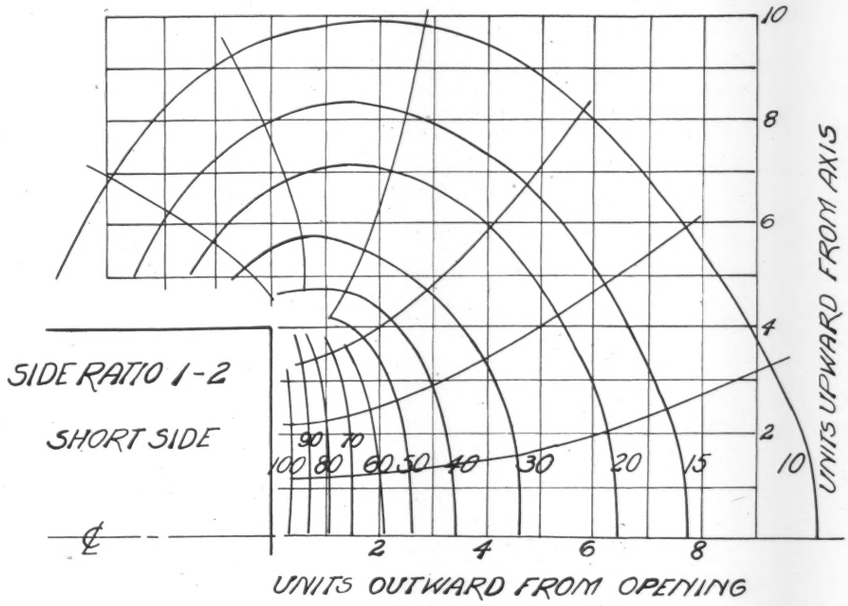


FIG. 5*a*—VELOCITY CONTOURS AND STREAM LINES FOR A RECTANGULAR OPENING WHOSE RATIO OF SIDES IS 1 TO 2—CONTOURS AND STREAM LINES IN RADIAL PLANE PERPENDICULAR TO LONG SIDE OF OPENING

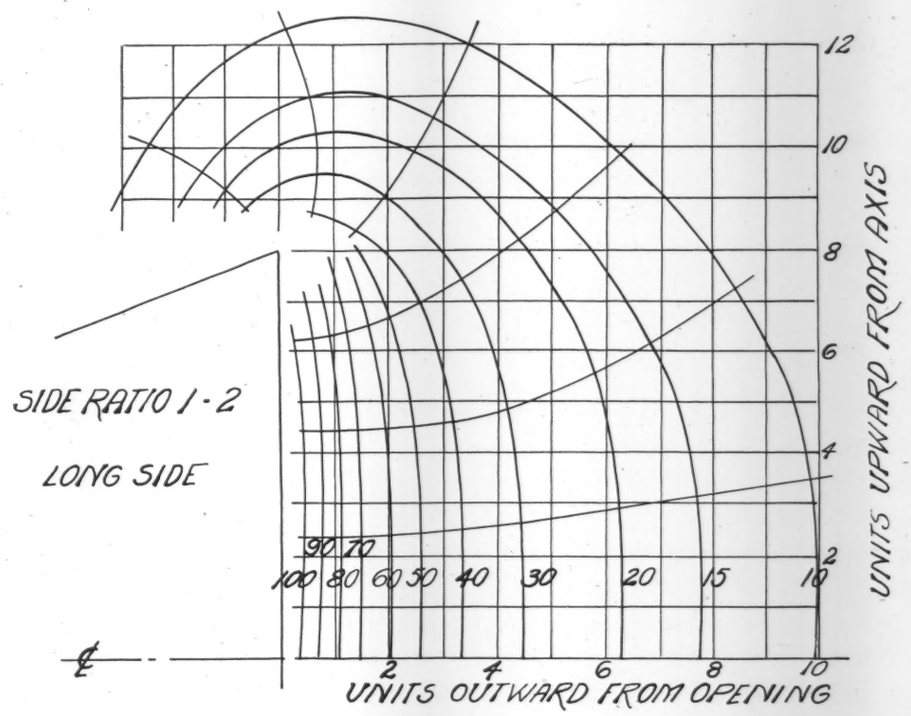


FIG. 5*b*—VELOCITY CONTOURS AND STREAM LINES FOR A RECTANGULAR OPENING WHOSE RATIO OF SIDES IS 1 TO 2—CONTOURS AND STREAM LINES IN RADIAL PLANE PERPENDICULAR TO SHORT SIDE OF OPENING

in Fig. 6b. The velocity at this point is approximately 12½ per cent of the velocity at the opening. Hence, the velocity at the opening being $\frac{1200 \times 144 \times 12}{4} =$ 3600 fpm, the velocity at the point must be $0.125 \times 3600 = 450$ fpm. The direction of flow may be obtained by drawing the tangent to the stream line at this point and is found to be equal to 30 deg of arc. These calculations assume that the flow in the region of influence is not grossly impeded by an obstruction. Otherwise, the contours are altered and must be redetermined with the obstruction in place.[3] It may be said, however, that if the obstruction is considerably smaller in cross sectional area than the surface area of the contour passing through it, the velocity distributions as shown in the figures are not substantially altered. The farther the obstruction is removed from an opening, the less is the error involved.

A matter of considerable importance is the velocity distribution over the hood opening. For the purpose of simplifying calculations, it has been assumed in developing the contours in Figs. 2 to 7, that the velocity distribution over the opening was uniform. Such an assumption is not correct as may be judged from an examination of the figures themselves, which show the 100 per cent contour to be somewhat displaced from the opening. In other words, the figures show a higher velocity than the average over the central portions of

[3] For an example of the type of obstruction included in this statement, see a paper by Hatch, Drinker and Choate, entitled, Control of the Silicosis Hazard in the Hard Rock Industries, I. Journal of Ind. Hygiene, XII, 3, March 1930, p. 87.

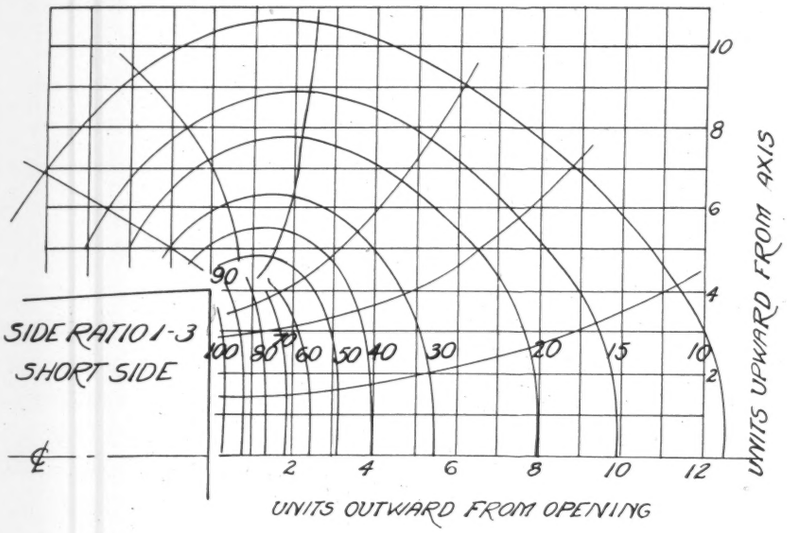


FIG. 6a—VELOCITY CONTOURS AND STREAM LINES FOR A RECTANGULAR OPENING WHOSE RATIO OF SIDES IS 1 TO 3—CONTOURS AND STREAM LINES IN RADIAL PLANE PERPENDICULAR TO LONG SIDE OF OPENING

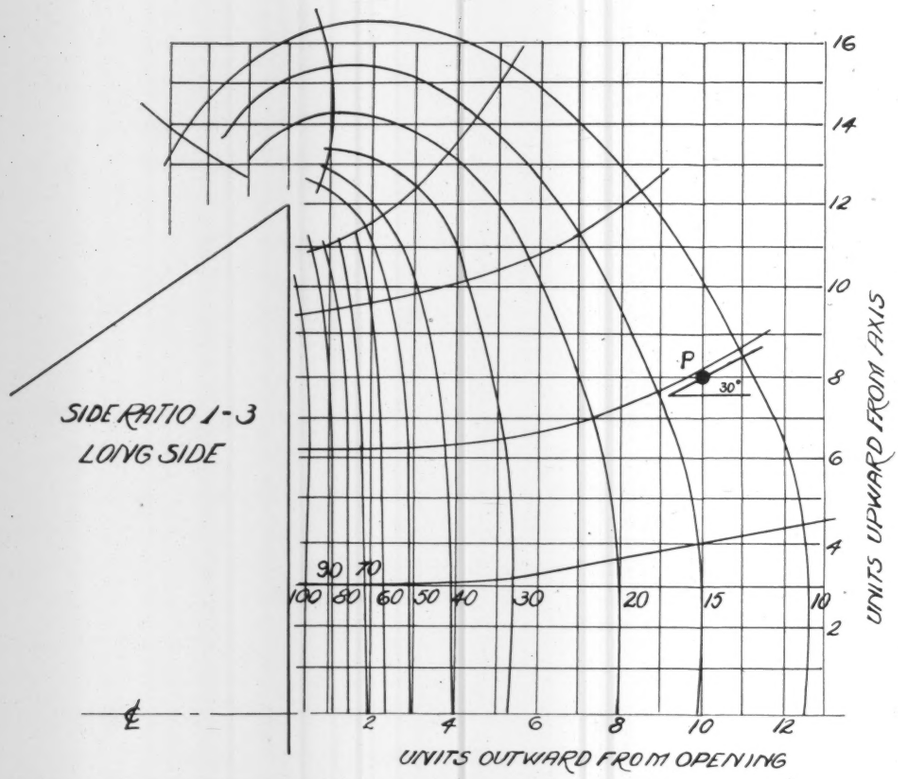


FIG. 6b—VELOCITY CONTOURS AND STREAM LINES FOR A RECTANGULAR OPENING WHOSE RATIO OF SIDES IS 1 TO 3—CONTOURS AND STREAM LINES IN RADIAL PLANE PERPENDICULAR TO SHORT SIDE OF OPENING

the opening. The situation is somewhat like the phenomenon occurring when a fluid flows through a pipe, which because of viscosity gives a higher velocity at the axis than toward the edges. The effect in the case of hoods does not, however, arise from similar considerations. In hood openings, it is necessary to contend with an *edge* effect. Air entering from behind the hood is forced to turn abruptly into it, thus creating a stationary vortex which restricts the effective area to a value less than the actual. At the corners of a rectangular hood, the effect may be considered as intensified. Experimental data tend to show that the effective area is reduced in proportion to the perimeter of the opening.

The *edge* effect may be considerably reduced by the use of a flange placed around the edge and lying in the plane of the opening. A flange approximately 5 in. in width is sufficient for hoods up to 3 sq ft in area. The flange tends to cut off the flow from the region behind the opening which is frequently useless, and is advantageous in two respects: *first*, it increases the effectiveness of the hood in the forward regions, and *second*, it reduces the energy consumption of the hood. In Fig. 7 the velocity contours and stream lines of a flanged circular opening are shown, and may be contrasted for the sake of clearness with the characteristics for the same opening in Fig. 2.

Formula and Nomograph to Determine the Axial Velocities of Hoods

An examination of Figs. 2 to 7 shows the interesting fact, that over the region projected by the edges of the opening, the velocity contours are parallel to its plane. It can be seen, therefore, that a formula giving the velocity outward along the axis of a hood under

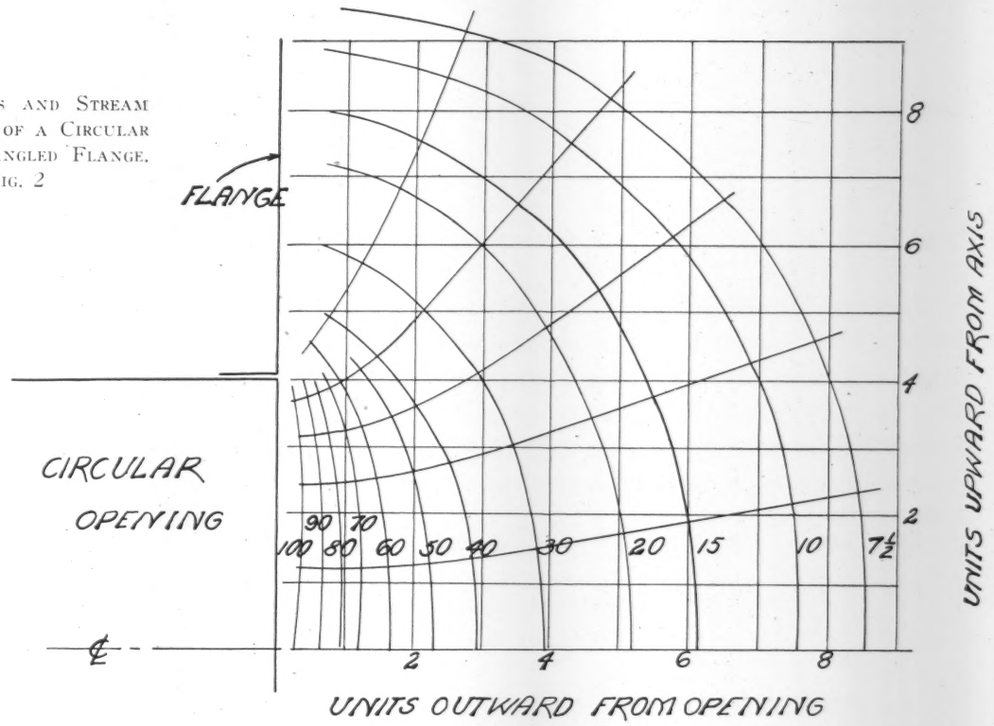


FIG. 7—VELOCITY CONTOURS AND STREAM LINES IN A RADIAL PLANE OF A CIRCULAR OPENING WITH A RIGHT ANGLED FLANGE. COMPARE WITH FIG. 2

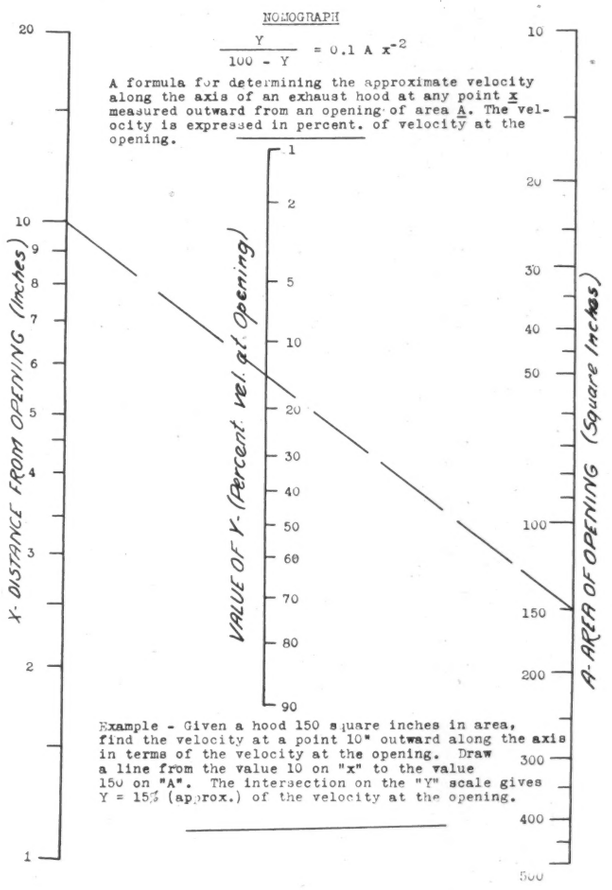

NOMOGRAPH
Y / (100 - Y) = 0.1 A x^-2
A formula for determining the approximate velocity along the axis of an exhaust hood at any point x measured outward from an opening of area A. The velocity is expressed in percent. of velocity at the opening.
X- DISTANCE FROM OPENING (Inches)
VALUE OF Y- (Percent vel. at Opening)
A- AREA OF OPENING (Square Inches)
Example - Given a hood 150 square inches in area, find the velocity at a point 10" outward along the axis in terms of the velocity at the opening. Draw a line from the value 10 on "x" to the value 150 on "A". The intersection on the "Y" scale gives Y = 15% (approx.) of the velocity at the opening.

FIG. 8—NOMOGRAPH FOR THE CALCULATION OF Y WHEN x AND A ARE GIVEN IN THE FORMULA

$$\frac{Y}{100 - Y} = 0.1 A x^{-2}$$

suction would be of considerable value. Such a formula has been developed for rectangular and round openings.[2] For the former, the formula has been found to be,

$$\frac{Y}{100 - Y} = 0.0833 \left[\frac{1}{1 + 0.259 \left(\frac{r}{1 - r} \right)^{-1.104}} \right] A^{1.04} x^{-1.91} \quad (1)$$

where

x = the distance outward along the axis measured in inches
A = the area of the opening in square inches
r = the ratio of sides (less than unity)
Y = the per cent velocity at the opening found at the point x

For circular openings, expressing A in terms of the diameter d, the formula is,

$$\frac{Y}{100 - Y} = 0.0645 d^{2.10} x^{-1.91} \quad (2)$$

A convenient and approximate formula, suitable for all shapes of openings is given by the relation

$$\frac{Y}{100 - Y} = 0.1 A x^{-2} \quad (3)$$

In these formulas the function $\frac{Y}{100 - Y}$ has been introduced in order that the physical limits of the problem might be satisfied. Thus, when $x = \infty$, $f(Y) = 0$, and when $f(Y) = 100$, $x = 0$. The fact that the velocity variation outward along the axis is very nearly as the inverse square of the distance, suggests that hood problems may be treated as though the openings were electrostatically charged plates. The mathematical treatment, however, except in very special cases, is exceedingly difficult. In order to simplify the calculation of Y, x or A when any two of these variables are known, the nomograph, Fig. 8, has been prepared. Its manner of use has been indicated in the figure.

[2]Studies in the Design of Local Exhaust Hoods, by Dallavalle and Hatch. (A paper presented at the Sixth Annual Wood-Industries Meeting, *American Society of Mechanical Engineers*, October 15, 16, 1931.)

Flue Action in High Buildings

By Harold L. Alt[1], New York, N. Y.
MEMBER

THE modern skyscraper is analogous to a high chimney with an exaggerated base. As a result, the air inside of such structures—when warmed above the existing outside temperature—tends to follow a chimney action and to flow upward. This gives rise to what is commonly termed *flue action in buildings*. For example, with a 40-story building averaging, say, 10 ft, floor to floor, the result is a chimney approximately 400 ft in height. With a minimum outside temperature of 0 deg F the theoretical draft in such a construction may be found from the following theoretical draft formula:

$$D_t = 0.52PH\left(\frac{1}{T_o} - \frac{1}{T_e}\right) \qquad (1)$$

where

D_t = the theoretical draft, inches of water
0.52 = a constant
P = absolute air pressure in pounds per square inch
H = height in feet
T_o = absolute temperature of atmosphere, degrees Fahrenheit
T_e = average absolute temperature of chimney gases, degrees Fahrenheit

For a 400-ft building and inside and outside temperatures of 70 F and 0 deg F, respectively, the theoretical draft is as follows:

$$D_t = 0.52 \times 14.7 \times 400 \times \left(\frac{1}{460} - \frac{1}{460 + 70}\right)$$

or 0.8805 in. of water.

Analogy Between Tall Building and Chimney

This draft very closely approximates that obtained

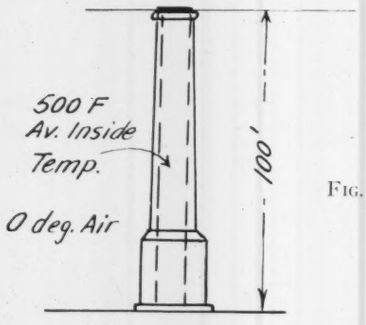


FIG. 1—100-FT OPEN CHIMNEY

in a 100-ft chimney on a zero day with an average temperature of the chimney gases of 500 F. In the case of the building, however, the top is closed and the conditions more nearly simulate a chimney whose outlet is stopped and in which little or no flow of gas takes place, although the average temperature is maintained. The maintaining of the temperature in the building, of course, is accomplished by means of the heating system and other sources of heat whereas in the chimney with the top permanently closed the high gas temperature would not continue for any length of time without some artificial means for compensating for the radiation from the shell.

It should be borne in mind, however, that the chimney has a continuous and uninterrupted opening from the top to the bottom as illustrated in Fig. 1 while the building has various horizontal stops formed by the floor construction as indicated in Fig. 2. It is probable that, if these horizontal stops were air tight, no more flue action would occur in the high building than occurs in the ordinary room where the warmer air is inclined to seek the ceiling. Unfortunately, the floors in a building have to be pierced at certain points to accommodate stair wells and elevator shafts; in fact, the higher the building, the more numerous are the perforations and the greater the area they are likely to include. When these openings are freely connected to the floor spaces without the interposing of partitions and doors, an upward flow of air is certain to result in cold weather and the inward leakage at the bottom and the outward leakage at the top will be greatly increased.

Compensating for Flue Action by Proportioning Heating Surface

Under such a condition the building corresponds to a chimney in which a flow of gas is taking place and this flow will be of a velocity necessary to set up a friction loss that exactly counter-balances the theoretical draft in the same manner as the flow of gas in a stack will be of such volume that the sum of all the draft losses will equal the theoretical draft produced by the average temperature difference and the height. It would be manifestly impractical to attempt to place sufficient heating surface in the bottom of a cold chimney to heat the incoming air from 0 deg F to 70 F and it would be even more difficult to hold the air at 70 F as it proceeds up the stack by means of auxiliary radiators installed at various heights from the bottom, owing to the fact that, as the outside air temperature changes, the flow of air in the stack changes and the radiation from the shell is altered. Yet this is to some extent comparable to the situation when an attempt is made to compensate for the flue action in a building by modifying the heating surface required in each floor and in each room in accordance with its height above some given level.

Practical Solution of Problem

A much more practical solution seems to lie in the closing off of all vertical openings from the various floors in as air-tight a manner as possible using partitions plastered on both sides and close fitting doors with self-closing door checks wherever conditions permit. Ele-

[1] Mechanical Equipment Engineer, Gibbs and Hill, New York, N. Y.

vator doors should be solid, elevator enclosures should be tight enclosures and stair wells should not run continuously from top to bottom but should be closed off with doors so as to form sections every 10 floors or so. Such construction, while not entirely eliminating flue action, will do much to minimize it.

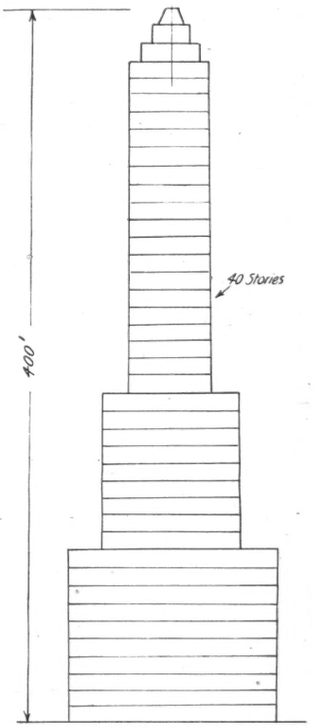


FIG. 2 — 40-STORY BUILDING

Wind Movement at High Altitudes

Another factor which enters into the problem is the matter of greater wind movement at high altitudes which tends to increase infiltration at the upper levels, and does much to offset flue action and the accompanying overheating to which the upper floors are subjected. One method of making allowance for this factor is to increase the heating surface on the upper floors in accordance with the schedule given in Table 1 and the use of automatic temperature control in some form to cut down the heat emitted on still days as well as when the outside temperature is above the minimum.

Where the surrounding buildings are an average of less than 20 stories it is advisable to increase the heating surface by 5 per cent down to the level at which some sheltering effect is received. These additions are over and above any help which may be received from the flue action but it is assumed that all elevator shafts and stair wells are as air-tight as they can be made.

Open Stair Wells

The open stair well running 10 or more stories is a much more difficult matter to handle and it is fortunate that such wells are not used for occupancy or much more elaboration in temperature control might be required. Openings of this character when closely boxed in with tight fitting, self-closing doors will be found to have temperatures from 20 to 40 deg higher at the top than at the bottom if the heating surface is located strictly in accordance with the heat losses resulting at each floor. One arbitrary method of handling this is to calculate the heating surface required for the stair well as a whole, then to place 50 per cent of this heating surface in the bottom third of the well, the normal heating surface in the middle third, and the balance in the top third, graduating the size of the radiators with the height of the building.

For example, if a stair well 10 stories high is considered and the total heating surface required is 400 sq ft, the bottom three stories would receive 50 per cent or 200 sq ft; the middle three stories about 133 sq ft, and the top four stories would take the remaining 67 sq ft. To grade this off the first story might be made 90 sq ft, the second 60 sq ft and the third 50 sq ft, thus giving a total of 200 sq ft on the first three levels. Then the fourth story might use 47 sq ft, the fifth 45 sq ft, and the sixth 41 sq ft, while the seventh would have 35 sq ft, the eighth 32 sq ft and the ninth and tenth nothing. The flue action in the well will equalize this inequality and may even more than equalize it. Incidentally this may also obviate the necessity of automatic control in such locations though, of course, automatic control will give superior results if it can be afforded.

Even automatic control will not make it unnecessary to install the greater proportion of heating surface near the bottom of the stair well because, if the surface in the bottom portion is inadequate, the opening of the radiator valves by the automatic control will not supply steam to sufficient surface to compensate for the flue action and the natural tendency for the air to rise as fast as it is heated. Fig. 3 illustrates a typical stair well treated in this manner.

It should be emphasized that this situation is not comparable to the flue action in an open chimney since the top of the stair well is closed off. Hence the previous statement regarding the impracticability of endeavoring to compensate for the flue action in a chimney by means of proportioning the heating surface does not apply in this case.

TABLE 1—ALLOWANCES ON DIRECT SURFACE FOR HIGHER STRATA AIR MOVEMENT

First 20 stories	add 0%
21st to 39th stories	add 5%
40th to 59th stories	add 10%
60th to 79th stories	add 15%
80th and above stories	add 20%

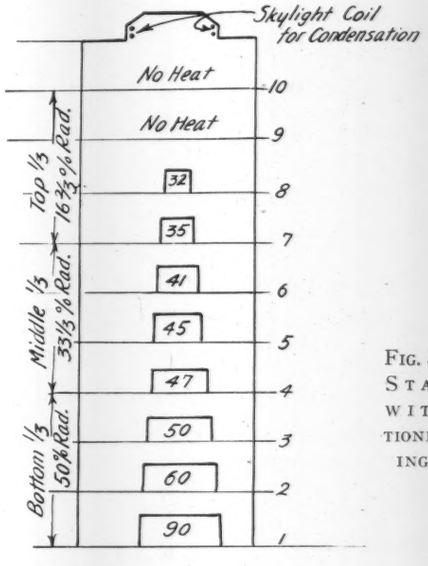


FIG. 3—TYPICAL STAIR WELL WITH PROPORTIONED HEATING SURFACE

Methods of Reducing Friction Heads in Pipe Fittings

By Joseph Le Grand[1], Chicago
NON-MEMBER

THE loss of head in pipe fittings is occasioned by friction of three principal kinds, namely, laminar friction, skin friction and turbulent friction, all of which are correlated and co-acting with viscosity and velocity. Velocity in turn co-acts through pressure. Skin and laminar resistances are small in practice. Turbulent resistance, representing the major part of the total loss, can be almost entirely eliminated by the adherence to streamline flow principles. Such designs are simple and practical, the author having experimentally produced numerous practical valves and fittings conforming with the physical laws surrounding fluid flow. It is the purpose of this paper to discuss the broader aspects of the subject and to suggest methods of reducing friction losses in valves and pipe fittings by the utilization of known physical principles.

A. S. H. V. E. Experiments

Giesecke and Badgett have shown,[2] in experiments with 1-in. tees, that when water enters at one end of the tee and 50 per cent is diverted through the branch, while 50 per cent flows straight through the tee, the loss of head for the diverted portion is equal to four elbows and the loss of head for the remaining 50 per cent, which flows straight through the tee, is equal to that in 0.6 elbow. These experimenters further state that before the tests had been performed it was believed that the loss of head for the portion of the water flowing straight through the tee would be practically zero and might even be negative.

Broadly speaking the results determined by Giesecke and Badgett relative to the resistance of valves and fittings to liquid or fluid flow have long been known, especially with reference to the flow of gases, all fluids being amenable to the same basic laws. Intensified research in aerodynamics brought about by the World War and its constructive continuance since has produced a large quantity of data of value to the other branches of applied science. Unfortunately, engineers in general have not made use of these data, except to a limited extent.

Reynolds' Number

It can be shown that a fluid flowing about similar obstructions will generate similar flows, regardless of the sizes of the obstructions, or the density or velocity of the fluid, or whether it is gaseous or liquid. When fluid flows are influenced by viscosity another condition must be fulfilled in order to obtain similarity. For example, let

μ = the viscosity
ρ = density
V = the velocity of the fluid
l = the length defining the obstruction

The quantity $\frac{\rho V l}{\mu}$, which is known as the Reynolds' Number, should have the same value in each motion to be compared, or viscosity will function differently in each case, and similarity of flow will not be possible. This quantity is of zero dimensions and is a pure number or ratio. It is independent of the units in which its separate factors are expressed, when those units form a dynamically consistent system, *i.e.*, a system of units which allows Newton's law of motion to be expressed, namely, that force equals mass times acceleration.

When a Reynolds' number is low, viscosity is high, as in oils. Water and inviscous fluids have high Reynolds' numbers. When the velocity is low the flow is generally streamline and remains so as the velocity is increased, until the critical velocity is reached, when it becomes turbulent. In fluids, such as water, the principal factors promoting streamline flow and preventing conversion into turbulent flow are (1) converging of solid boundaries and (2) curvature of the path with the greatest velocity on the outside. Turbulence is caused by tangential flow at solid boundaries. When two streams are moving at different velocities the surface of separation is invariably unstable. Streamline flow stability is increased by convergence and decreased by divergence, turbulent flow being more prevalent with divergence and velocity reduction.

Reynolds gives the critical velocity as inversely proportional to the diameter of the pipe, or

$$v_k = \frac{P}{bd} \qquad (1)$$

where

$P = \mu/\rho$
b = a constant
d = diameter
v_k = critical velocity

Where the unit of length is the foot, b is equal to 25.8 for the lower critical velocity, and 4.06 for the higher critical velocity, while if t equals temperature in degrees centigrade,

$$P = \frac{1}{1 + 0.03368t + 0.000221t^2} \qquad (2)$$

A more general expression for the lower critical ve-

[1] Consulting engineer and physicist.
[2] Friction Heads in One-Inch Standard Cast-Iron Tees, by F. E. Giesecke and W. H. Badgett (*Heating, Piping and Air Conditioning*, May, 1931); also Supplementary Friction Heads in One-Inch Cast-Iron Tees (*Heating, Piping and Air Conditioning*, January, 1932).

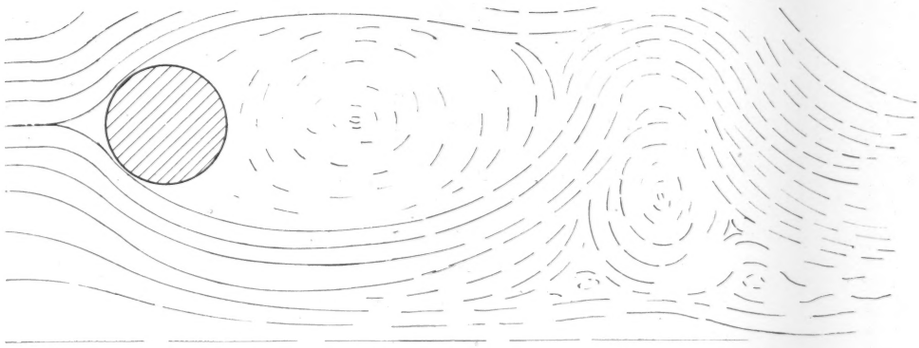


FIG. 1 (LEFT)—DIAGRAM ILLUSTRATING TYPICAL TURBULENT FLOW

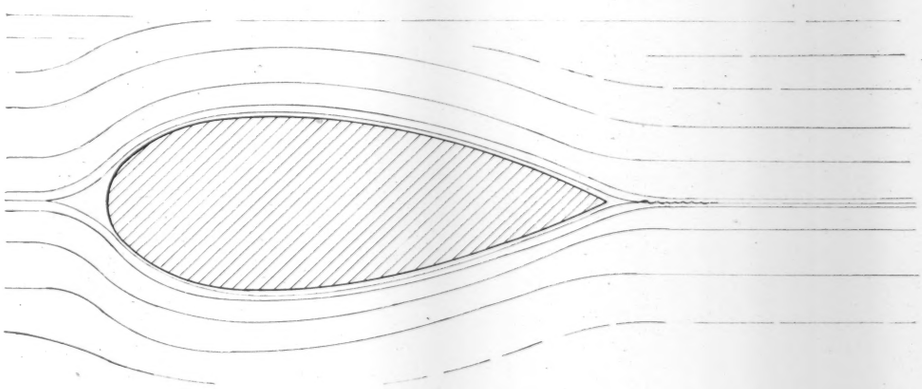


FIG. 2 (RIGHT)—DIAGRAM ILLUSTRATING TYPICAL STREAMLINE FLOW

locity in a parallel pipe, applying to any fluid or system of units, may be stated as follows:

$$\nu_k = \frac{2000\mu}{dP} \tag{3}$$

For water at 0 deg C,

$\mu/\rho = 1.92 \times 10^{-5}$ (in foot-pound-second units), so that

$$\nu_k = \frac{0.0384}{d} \text{ feet per second (where } d \text{ is in feet)} \tag{4}$$

Turbulent and Streamline Flow

Fig. 1 represents turbulent flow about a cylinder and clearly shows the high resistance offered by bodies or projections promoting turbulent flow. Such turbulent flow does not yet lend itself to mathematical treatment. Streamline flow, as shown in Fig. 2, has been thoroughly investigated mathematically. Actual streamline flow is practically the theoretical flow and the resulting pressure upon the surface of bodies is relatively small, the resistances offered being principally due to tangential forces or skin friction. Figs. 1 and 2 illustrate the importance of avoiding turbulent flow and of adherence to streamline flow.

Energy treatment of theoretical flow is attributed to Froude and is valuable in presenting a definite idea of the exchange of energy involved. Fig. 3 shows the method used by Froude to illustrate exchange of energy by assuming the fluid in the vicinity of the body to be divided into a large number of tubes of flow. Ahead of the body in the as yet undisturbed portion of the stream, the fluid energy will be that due to the static pressure p_o of the stream and the kinetic energy head of V_o, the undisturbed velocity.

By Bernouilli's theorem this remains constant along any tube of flow, and is equal to

$$\frac{p_o}{\rho_o} + \frac{V_o^2}{2g} = C = \frac{p}{\rho} + \frac{V^2}{2g} \tag{5}$$

Again referring to Fig. 3 in the portion L of the body, the tubes of flow widen out, the kinetic energy head and the velocity decrease, and the pressure on the body becomes greater than the static pressure p_o. It is therefore evident that the nose of the body performs work upon the fluid contacting with it. This is further evident by consideration of the curvature effect and the resultant centrifugal force. In the section M of the body the tubes are crowded, the velocity increases, and the pressure on the body is less than p_o, or under actual suction, while the fluid is performing work upon the body. It can be further shown that the portion N works upon the fluid and in the portion P the fluid works upon the body. By this balance it is found that the work done upon the body is equal to zero.

Again referring to Figs. 1 and 2, it may be stated, for the purpose of illustrating the enormous amount of difference in resistance existing between the two types of flow, that assuming the minor axis of the streamline body (Fig. 2) to be equivalent to the diameter of the cylinder (Fig. 1) at a Reynolds' number of 100,000, the turbulent flow shown causes approximately 25 times as much resistance to flow as that caused by the streamline action.

Credit is due Giesecke and Badgett for their ingenuity

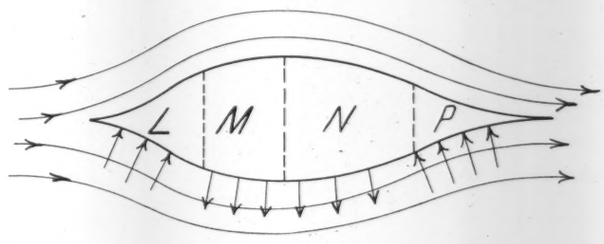


FIG. 3—AN ILLUSTRATION OF FORCE REVERSAL EQUATION OF STREAMLINE FLOW FROM ENERGY CONSIDERATION

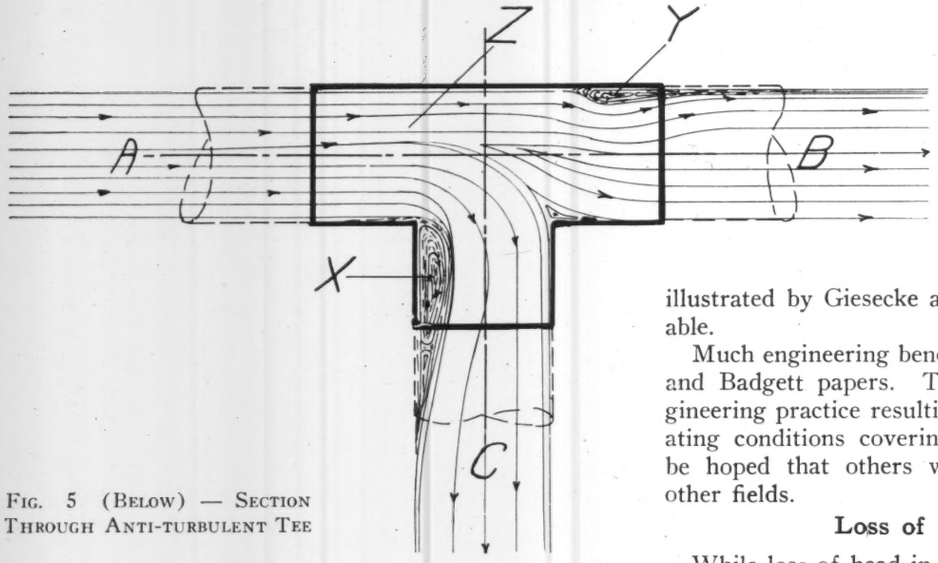
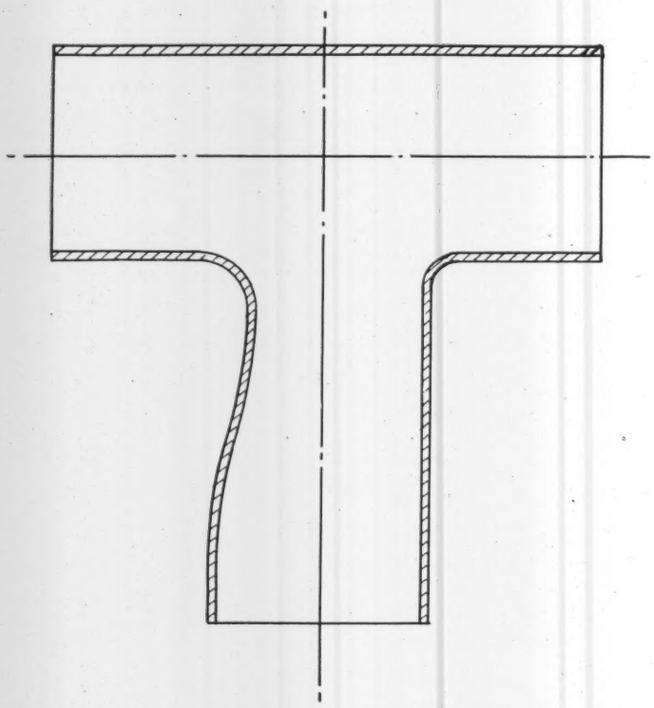


FIG. 4—FLUID FLOW THROUGH A TEE WITH 50 PER CENT DIVERTED THROUGH BRANCH. COUNTER-CLOCKWISE TURBULENT EDDY SHOWN AT *Y* AND CLOCKWISE LOW PRESSURE AND TURBULENT EDDY AT *X*. POINT *Z* INDICATES UNSTABLE FLUID ZONE

FIG. 5 (BELOW) — SECTION THROUGH ANTI-TURBULENT TEE



in preparing Fig. 3 of the paper entitled Supplementary Friction Heads in One-Inch Cast-Iron Tees, wherein liquid streamline and turbulent flow were made visible by gas bubbles. This figure shows a liquid following the clearly and well-established laws of fluid flow, pointing out the throttling effect in a run *AB* and the points of turbulent resistance in both the run *AB* and the branch *C*, the resultant resistance of which is of course obvious. The resistance of a tee, or other fitting, is in proportion to the energy spent upon laminar and skin friction and the low pressure turbulent eddys developed.

It is difficult to comprehend why any experimenters, in view of the amount of data available upon fluid flow, would presume that the resistance to liquid flow in the run of the tee would equal zero. It is still more difficult to understand why any one should anticipate a negative result with a turbulent formation of known magnitude existing in the run after the branch connection. From a study of the fundamental action of fluids the results illustrated by Giesecke and Badgett are directly deductable.

Much engineering benefit can result from the Giesecke and Badgett papers. They clearly point out poor engineering practice resulting in large losses and bad operating conditions covering an extensive field. It is to be hoped that others will publish similar findings in other fields.

Loss of Head in Valves

While loss of head in tees is apparently unappreciated by a large percentage of engineers, the losses occasioned in valves, especially globe and check valves, are particularly high. By means of the proper design of valves

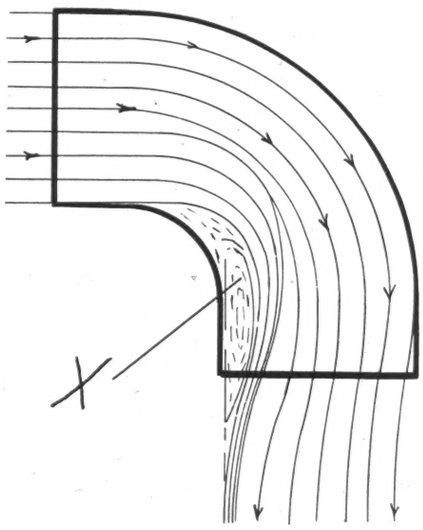


FIG. 6—FLUID FLOW THROUGH AN ELBOW SHOWING MAJOR CLOCKWISE EDDY AT POINT *X*

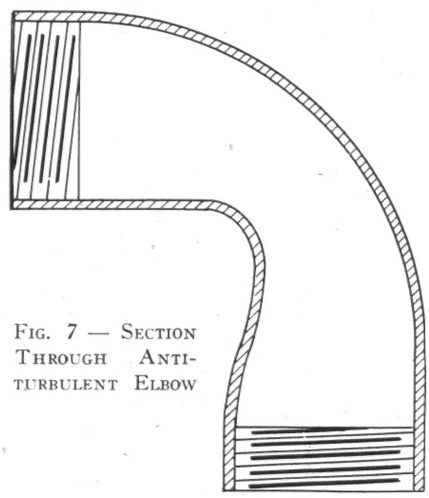


FIG. 7 — SECTION THROUGH ANTI-TURBULENT ELBOW

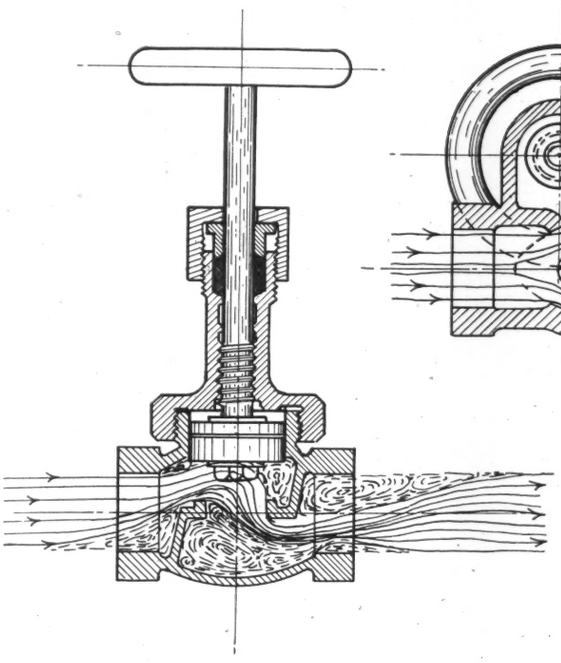


Fig. 8—Fluid Flow Through Typical Globe Valve Showing Two Major Low Pressure Turbulent Zones and Four Minor Zones of High Resistance. The Lower Turbulence Is Clockwise in Rotation and the Upper Zones Counter-clockwise

and fittings a large part of uselessly expended energy may be saved.

With the exception of large-radius or long-sweep elbows which are used occasionally, little or no attention has been paid by valve and pipe-fitting designers to factors other than those which are of a purely mechanical or production nature. As a concrete example of this statement the author would cite the globe valve. In the first place a valve has two principal functions to perform, not one as would appear from conventional designs. One of these factors is ability to close a line

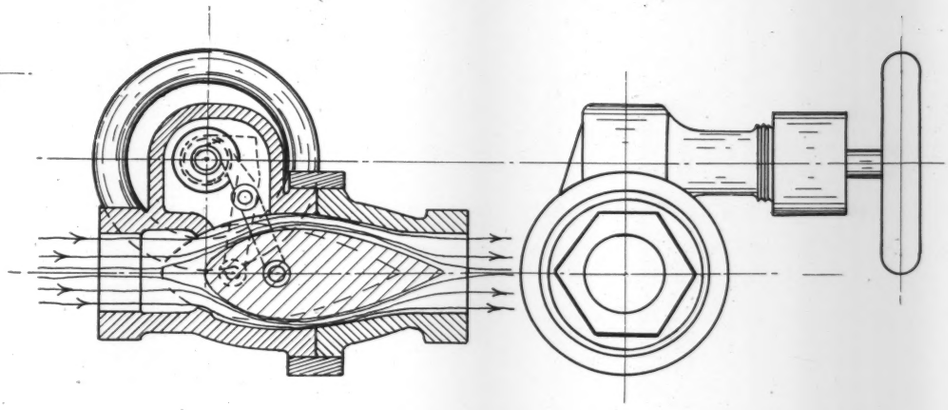


Fig. 9—Diagrammatic Sketch of a Design Proposed by the Author for a Streamline Anti-turbulent Valve Illustrating a Side Stem Split Body Type

against fluid flow and the other one is to permit a free fluid flow through it when desired. This second and important factor has been entirely ignored by valve designers.

Suggested Designs for Reducing Friction

The accompanying figures graphically illustrate fluid flow through a tee, an elbow and a conventional globe valve, and also show means of reducing these losses. Fig. 4 represents flow through a conventional tee with 50 per cent of the flow diverted, showing the turbulence set up in both the run and branch as well as the throttling effect caused thereby in the run. Fig. 5 represents the author's method of eliminating this turbulent friction in a tee. Fig. 6 represents fluid flow in a standard elbow illustrating the points of loss, and Fig. 7 represents a method of avoiding such loss. Fig. 8 represents a standard globe valve and shows clearly the difficulties encountered by a stream of fluid to effect passage through the valve. Fig. 9 represents the author's ideas of a valve design.

Recovering the Heat from Exhaust Steam

Large industrial plants, hotels and office buildings still find it profitable to maintain their individual power plants if care is taken in the utilization of the exhaust steam, especially for heating purposes.

The exhaust steam may be circulated directly through the heating units of a heating, ventilating or air conditioning system, or it may be used for heating water which in turn may be circulated through similar elements of a hot water heating system. It may also be used for domestic hot water heating.

Frequently there is a fluctuating load on the power or electric generating apparatus which in turn produces fluctuating quantities of exhaust steam. The quantity of steam required for heating is also variable. These two variables do not, as a rule, coincide so that the total quantity of exhaust steam produced may be either a certain percentage less or a certain percentage more than the total quantity of steam required for heating, or for heating and ventilating either during the heating season or throughout the year. These relations change throughout the day and night and throughout the seasons of the year.

There are also wide variations in the heating requirements due to changes in weather conditions and wide variations in the exhaust produced due to such changes as in the demands for lighting on dark or light days, for elevator power during rush or slack periods, for air conditioning on good or bad days and for many other variables in the demands for power or light, depending on the character of building and its operating requirements.

The way in which the quantities of exhaust steam produced and the quantities of steam required during the various intervals of time throughout the year coincide will determine how much may be used, how much must be thrown away and how much live steam must be used to supplement the exhaust steam deficit, unless some means is adopted for adjusting the supply to the demand.

Lincoln Memorial Drive Along the Shore of Lake Michigan

Three Wonderful Days in Milwaukee

WHEN the Society's Semi-Annual Meeting 1932 opens in Milwaukee June 27, the Wisconsin Chapter members, under the leadership of John S. Jung, general chairman of arrangements, will stage a program that will be full of pleasant surprises and still will be in step with the times.

The Milwaukee meeting promises something different both at the technical sessions and in the program of recreation and entertainment for the ladies.

Society business of the utmost importance will come before the meeting in the Hotel Pfister when President F. B. Rowley calls the meeting to order on Monday morning, June 27 at 10 o'clock (Standard Time). The Program Committee has selected nine papers for discussion at the *three* morning sessions so that ample time will be available to consider the committee report on the Revision of Constitution and By-Laws and the Ventilation Standards.

Much hard work has been done by Mr. Driscoll and his Committee on Ventilation Standards since the Annual Meeting in Cleveland so that this report is awaited with much interest because of its great importance to the profession and industry. Minimum requirement standards based on the known scientific principles have been formulated to meet the needs of architectural, engineering and health authorities.

Changes in the Society's Constitution and By-Laws will be offered for consideration by W. T. Jones and his committee. A complete revision of the rules has been undertaken in an effort to simplify them and provide an improved procedure in Society operation. The resultant report summarizes the many suggestions offered during the past several years by members who have had experience in administration and committee work.

These and other committee reports will be submitted and opportunity will be afforded for committee conferences during this three-day summer meeting.

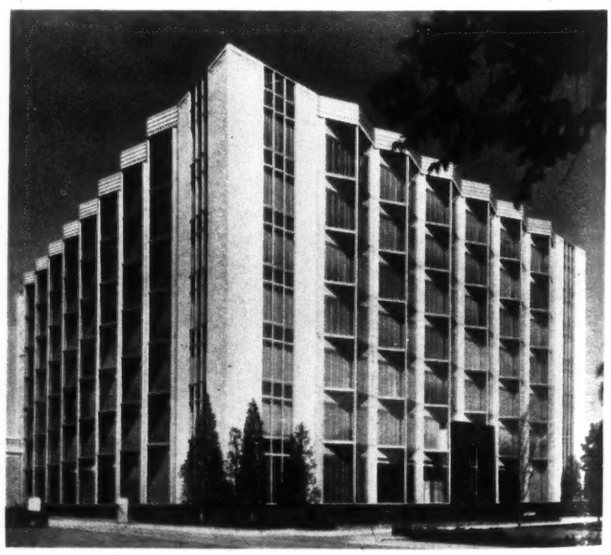
While the object of Society meetings is essentially to advance the heating and ventilating art, some time has been set aside so that the Wisconsin members, who are our hosts, may entertain the out-of-town members and ladies.

A hearty welcome will be given by John Shodron's and Prof. Larson's Committees on Reception and Registration. An information service will be provided at Registration Headquarters on the 7th floor of Hotel Pfister where badges, programs and tickets for the various functions will be available.

Every effort has been made to arrange an especially attractive program for the visiting ladies whose entertainment will be in the hands of C. H. Randolph and Mrs. E. A. Jones with the other chapter ladies as hostesses.

On Monday at noon the visiting ladies will be entertained at a luncheon followed by bridge. In the evening they join the men at an entertainment, dance and buffet supper on the Hotel Pfister roof.

Tuesday morning the ladies will visit a nationally famous



Research Building of the A. O. Smith Corp.

hosiery factory and the local downtown department stores. In the afternoon an inspection will be made of Hotel Pfister art gallery and the period rooms and suites. The evening will be devoted to the semi-annual banquet and dance in the Fern Room of the hotel.

Wednesday morning a trip around the city is planned via the lake shore boulevard, and brief stops at the museum and zoo.

The men will have some special events to engage their attention when the business and technical sessions are over. E. A. Jones, president of the Wisconsin Chapter, has charge of the golf and the Research Cup Tournament will be held at Ozaukee Country Club on Monday afternoon. Cars will leave Hotel Pfister at 12:30 and again at 1 p. m. Arrangements have been made so that members may get lunch at the club house if they desire.

For those who do not play golf, arrangements have been made for a trip to the A. O. Smith Laboratories, and cards or other sports at the Country Club are being provided.

Upon completion of the tournament and trips, the members will join the ladies for the evening's entertainment on the hotel roof garden where Tyrolean musicians will entertain and a Dutch lunch will be served at 9 o'clock. Dancing will continue until midnight.

On Tuesday afternoon inspection trips to industrial plants have been arranged and members should indicate their choice when filling out their registration cards.

The feature of the entertainment program will be the banquet and dance in the Fern Room Tuesday evening at 7:30 p. m. The golf and bridge trophies will be awarded and a musical and entertainment program will be given during dinner.

Much study has been given this year to the expense of attending the meeting with the following results:

1. Reduced railroad fares will be in effect.
2. Hotel rates for room and meals are moderate.
3. Dutch lunch and banquet tickets—both affairs at the usual dinner cost.
4. Greens fee and caddy fee for golfers at low rate.

As Milwaukee is the gateway to the Land of Lakes and the Wisconsin Woods, attendance at the meeting is a fine start for a vacation tour by train or auto. Low fares and de luxe trains are available in June.

For three wonderful days, come to the Milwaukee meeting of the A. S. H. V. E., June 27-29. It's a step that you'll never regret.

SCHEDULE OF EVENTS

American Society of Heating and Ventilating Engineers

Hotel Pfister, Milwaukee, Wis., June 27-28-29, 1932

(All Events on Standard Time)

Monday, June 27

8:30 a. m. Registration (7th Floor).
10:00 a. m. Technical Session (Fern Room).
12:15 p. m. Ladies leave Hotel Pfister for luncheon and bridge.
12:30 p. m. Golfers leave Hotel Pfister for Ozaukee Country Club.

West Wisconsin Avenue, Showing Part of Central Business District

1:00 p. m. Luncheon Ozaukee Country Club.
1:30 p. m. Tournament (Research Cup) 18 Holes.
2:30 p. m. Visit to A. O. Smith Laboratories.
6:30 p. m. Council Dinner-Meeting.
8:30 p. m. Entertainment, Dance, Dutch Lunch (Wisteria Room, 9th Floor).

Tuesday, June 28

9:30 a. m. Technical Session (Fern Room).
10:30 a. m. Ladies Visit Hosiery Mill.
12:30 p. m. Luncheon—Nominating Committee.
2:00 p. m. Ladies Visit Pfister Art Gallery and Period Rooms.
2:30 p. m. Inspection of Industrial Plants.
7:30 p. m. Banquet and Dance (Fern Room).

Wednesday, June 29

9:30 a. m. Technical Session.
10:30 a. m. Ladies Auto Trip (Lake Shore, Museum, Zoo)

John S. Jung is General Chairman of Arrangements and he will be assisted by the following committee chairmen: Advisory, H. W. Ellis; Reception and Registration, G. L. Larson; Transportation, A. M. Wagner; Finance, V. A. Berghoefer; Entertainment, H. F. Haupt; Golf, E. A. Jones; Banquet, F. G. Weimer; Publicity, Ernest Szekely; Ladies' Entertainment, C. H. Randolph and Mrs. E. A. Jones, Hostess.

Mitchell Park Conservatory and Sunken Garden

Research Suggestions Classified

The Society's Committee on Research has made a final analysis of the replies and suggestions received in response to its circular letter of June 20, 1931, sent to all members of the Society, relative to the research interests of the membership.

It was the purpose of that inquiry to secure a comprehensive view of what the Society as a whole felt should be the scope and character of the research work undertaken or sponsored by the Society. More than 50 replies presenting several hundred suggested research projects have been received and analyzed by the Committee on Research. A preliminary report on some of the earlier replies appeared in the September, 1931, issue of *Heating, Piping and Air Conditioning*, pages 797 to 799.

This final analysis divides the projects rather broadly into three groups as follows:

1. Suitable for Society research—fundamental in character.
2. Suitable for investigation under direction of the Committee on Research if sponsored and financed by the group directly interested.
3. Beyond the scope of the Committee on Research as at present organized.

Each group contains a number of classifications and the variety and character of items and examples given under each classification indicates the general policy which has been followed in making this analysis. It is hardly necessary to point out the fact that since the Committee on Research has approved the analysis as herewith presented, it will be the policy of the Committee to restrict its selection of research projects financed from the Society Research funds to such basic or fundamental matters as appear in List No. 1. Certain other types of projects which may be specially financed by the group interested appear in List No. 2, while types of projects beyond the scope of the Committee appear in List No. 3.

The Committee wishes to express its sincere appreciation of the valuable comments and suggestions which have been received and which have made possible this survey and this announcement of policy by the Committee on Research.

List No. 1

Projects Suitable for Society Research

(More or less basic in character not likely to be studied by any one agency except a national research laboratory. The order of presentation has no significance.)

I. Heat transmission of building materials, under both winter and summer conditions, including conductivity and surface coefficients. Also, the coordination of results from such important sources as U. S. Bureau of Standards and A. S. H. V. E. Laboratory.

II. Heat capacity of building materials, including solar effects, night and day conditions, and effect on proper heat transmission coefficients for use under such conditions.

III. Aeration of buildings by natural causes, including wind, temperature difference, shape and height of building.

IV. Heat transfer of pipes and metallic surfaces, including direct and indirect surfaces for heating and cooling for both convection and forced circulation of air, gas and water. Also, insulation for hot surfaces.

V. Physiological studies of effect of various atmospheric conditions on human health and comfort, in order to determine the ventilation requirements essential to health.

VI. Air pollution and purification, including smoke, dust, and fumes.

VII. Methods of introducing air into and extracting air from rooms or other spaces.

VIII. Development of a comfort meter or indicator which will integrate all factors in accordance with a simple index.

IX. Flow of fluids in pipes, tubes, ducts, and all kinds of special fittings.

a Flow of hot water in the mains, branches, and risers under gravity and forced circulation conditions and in steam heating returns.

b Flow of steam in mains, branches, riser and return lines under heating service conditions.

c Flow of air in round and rectangular ducts, elbows, special fittings and through grilles, nozzles and deflectors under gravity and forced circulation conditions.

X. Combustion of fuels—solid, liquid, and gaseous, using a few general types of commercial apparatus to establish basic principles only. Heat transfer of both direct and indirect surfaces.

XI. Sound and noise effects, and methods of measurement. Acoustical insulation for heating and ventilating systems and equipment.

XII. Corrosion problems of all kinds related to heating and ventilating work.

List No. 2

Projects Suitable for Investigation under Direction of Committee on Research if Sponsored and Financed by the Group Interested.

(Such investigations usually involve largely commercial problems.)

I. Performance data on general types of existing equipment and materials used in heating and ventilating practice, with the sole purpose of outlining or defining suitable codes for testing and rating such equipment.

Examples

Reducing valve performance for heating conditions.
Unit heater performance for heating conditions.
Unit cooler performance for cooling conditions.
Fuel burning devices, such as coal stokers, oil burners, and gas burning units.
Steam boilers and hot water heaters.
Air washers for cleaning and humidifying and dehumidifying.
Air filters for cleaning.
Insulating materials for low, medium and high temperature conditions.
Condensation traps and valves for radiators, steam containers and piping systems.
Condensation and vacuum pumps.
Fans for heating and ventilating work.
Pumps for forced hot-water heating.

II. Codes of all kinds, as well as the testing and rating codes mentioned in item I come under this section, provided an interested group or a special committee of the Society will sponsor and finance the matter to be investigated.

List No. 3

Projects Beyond the Scope of the Committee on Research as at Present Organized.

(Such projects are strictly within the province of the consulting engineer.)

I. Surveys and reports on heating and ventilating systems for various types or kinds of buildings.

As for example:

Libraries, office buildings, elevator machinery rooms, factories, theaters, laundries, chemical laboratories.

II. Comparisons of and reports on different types of heating and ventilating systems for a given building.

As for example:

Steam vs. hot-water heating vs. electrical heating.
Direct vs. indirect heating systems, whether steam, water, direct fired or electricity.
Open tank vs. closed tank hot-water heating.
Temperature control and regulation.

III. Comparisons and reports on efficiencies and capacities of different commercial types of heating and ventilating equipment for individuals.

As for example:

Various types or makes of fans, pumps, radiators, boilers, heaters, furnaces, washers, filters, valves, motors, and all kinds of accessories.

Bibliography of A. S. H. V. E. Papers and Articles on Air Conditioning

Definitions

AIR CONDITIONING: The simultaneous control of the temperature, humidity, air motion and air distribution within an enclosure. Where human comfort and health are involved, a reasonable air purity with regard to dusts, bacteria and odors is also included. (A. S. H. V. E. GUIDE 1932.)

COMFORT LINE: The effective temperature at which the largest percentage of adults feel comfortable. (A. S. H. V. E. GUIDE 1932.)

COMFORT ZONE: The range of effective temperatures over which the majority (50 per cent or more) of adults feel comfortable. (A. S. H. V. E. GUIDE 1932.)

EFFECTIVE TEMPERATURE: An arbitrary index of the degree of warmth or cold felt by the human body in response to temperature, humidity and movement of the air. The numerical value of the effective temperature scale has been fixed by the temperature of saturated air which induces an identical sensation of warmth.

List of Papers and Articles

*Absorption of Solar Radiation in Its Relation to Temperature, Color, Angle and other Characteristics of the Absorbing Surface, by F. C. Houghten and Carl Gutberlet (A. S. H. V. E. TRANSACTIONS, Vol. 36, 1930).

*Acoustical Problems in the Heating and Ventilating of Buildings, by Vern O. Knudsen (*Heating, Piping and Air Conditioning*, December 1931).

Advance in Air Conditioning in School Buildings, by E. S. Hallett (A. S. H. V. E. TRANSACTIONS, Vol. 26, 1920).

Air Conditioning Apparatus (A. S. H. V. E. GUIDE 1932).

Air Conditioning as Applied to Furniture, Fixtures and Other Interior Woodwork, by D. R. Brewster (*Heating, Piping and Air Conditioning*, January 1931).

Air Conditioning for Industrial Purposes (A. S. H. V. E. GUIDE 1932).

*Air Conditioning for Railway Passenger Cars, by A. H. Candee (*Heating, Piping and Air Conditioning*, December 1930).

*Air Conditioning for Sausage Manufacturing Plants, by M. G. Harbula (A. S. H. V. E. TRANSACTIONS, Vol. 28, 1922).

Air Conditioning for Summer and Winter Comfort, by W. H. Carrier (*Heating, Piping and Air Conditioning*, September 1930).

Air Conditioning in Relation to Comfort and Health (A. S. H. V. E. GUIDE 1932).

Air Conditioning in the Bakery, by W. L. Fleisher (*Heating, Piping and Air Conditioning*, February 1931).

Air Conditioning in the Printing Industry, Relation of Standardization to, by W. H. Carrier (*Heating, Piping and Air Conditioning*, April 1931).

Air Conditioning Problems, by F. C. Houghten, W. E. Miller and W. P. Yant (A. S. H. V. E. TRANSACTIONS, Vol. 35, 1929).

*Air Conditioning System of a Detroit Office Building, by H. L. Walton and L. L. Smith (A. S. H. V. E. TRANSACTIONS, Vol. 35, 1929).

*Air Conditioning the Halls of Congress, by L. L. Lewis and A. E. Stacey (A. S. H. V. E. TRANSACTIONS, Vol. 36, 1930).

*Air Cooling by Refrigeration, by W. W. Macon (A. S. H. V. E. TRANSACTIONS, Vol. 15, 1909).

Air Motion, High Temperatures and Various Humidities—Reactions on Human Beings, W. J. McConnell, F. C. Houghten and C. P. Yaglou (A. S. H. V. E. TRANSACTIONS, Vol. 30, 1924).

Air Washing and Humidification for School Buildings, by Perry West (A. S. H. V. E. TRANSACTIONS, Vol. 25, 1919).

Application of Air Conditioning to Premature Nurseries in Hospitals, by C. P. Yaglou, Philip Drinker and K. D. Blackfan (A. S. H. V. E. TRANSACTIONS, Vol. 36, 1930).

*Atmospheric Air in Relation to Engineering Problems, by Hermann Eisert (A. S. H. V. E. TRANSACTIONS, Vol. 33, 1927).

Basal Metabolism Before and After Exposure to High Temperatures and Various Humidities, by W. J. McConnell, C. P. Yaglou and W. B. Fulton (A. S. H. V. E. TRANSACTIONS, Vol. 31, 1925).

Body Temperatures and Their Measurements, by W. J. McConnell and F. C. Houghten (A. S. H. V. E. TRANSACTIONS, Vol. 28, 1922).

Body Temperature Regulations and Other Physiological Reactions in Their Relation to the Physical Characteristics of Man's Atmospheric Environment, by F. C. Houghten and W. W. Teague (A. S. H. V. E. TRANSACTIONS, Vol. 35, 1929).

Changes in Ionic Content of Air in Occupied Rooms Ventilated by Natural and by Mechanical Methods, by C. P. Yaglou, L. Claribel Benjamin and Sarah P. Choate (*Heating, Piping and Air Conditioning*, October 1931).

*Combination Ventilating, Heating and Cooling Plant in a Bank Building, by A. M. Feldman (A. S. H. V. E. TRANSACTIONS, Vol. 15, 1909).

Comfort Zone for Men at Rest and Stripped to the Waist, by C. P. Yaglou (A. S. H. V. E. TRANSACTIONS, Vol. 33, 1927).

Cooling an Auditorium by Means of Ice, by J. J. Harris (A. S. H. V. E. TRANSACTIONS, Vol. 9, 1903).

Cooling and Humidifying of Buildings, by S. C. Bloom (A. S. H. V. E. TRANSACTIONS, Vol. 35, 1929).

Cooling Effects on Human Beings Produced by Various Air Velocities, by F. C. Houghten and C. P. Yaglou (A. S. H. V. E. TRANSACTIONS, Vol. 30, 1924).

Cooling of Closed Rooms, by Hermann Eisert (A. S. H. V. E. TRANSACTIONS, Vol. 2, 1896).

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Dehumidification Methods, by M. C. W. Tomlinson (A. S. H. V. E. TRANSACTIONS, Vol. 33, 1927).

Determination of the Comfort Zone, by F. C. Houghten and C. P. Yagloglou (A. S. H. V. E. TRANSACTIONS, Vol. 29, 1923).

Determining Lines of Equal Comfort, by F. C. Houghten and C. P. Yagloglou (A. S. H. V. E. TRANSACTIONS, Vol. 29, 1923).

Drying as an Air Conditioning Problem, by A. W. Lissauer (A. S. H. V. E. TRANSACTIONS, Vol. 27, 1921).

Effective Temperature Applied to Industrial Ventilation Problems, by C. P. Yagloglou and W. E. Miller (A. S. H. V. E. TRANSACTIONS, Vol. 30, 1924).

Effective Temperature for Persons Lightly Clothed and Working in Still Air, by F. C. Houghten, W. W. Teague and W. E. Miller (A. S. H. V. E. TRANSACTIONS, Vol. 32, 1926).

Effective Temperature with Clothing, by C. P. Yaglou and W. E. Miller (A. S. H. V. E. TRANSACTIONS, Vol. 31, 1925).

Experiments in Air Conditioning the Home, by E. R. Hayhurst (A. S. H. V. E. TRANSACTIONS, Vol. 25, 1919).

Experiments on Humidifying Air at the Oliver Wendell Holmes School, by C. F. Eveleth (A. S. H. V. E. TRANSACTIONS, Vol. 19, 1913).

*Field Studies of Office Building Cooling, by J. H. Walker, S. S. Sanford and E. P. Wells (*Heating, Piping and Air Conditioning*, February 1932).

Further Study of Physiological Reactions, by W. J. McConnell, F. C. Houghten and F. M. Phillips (A. S. H. V. E. TRANSACTIONS, Vol. 29, 1923).

*Heat and Moisture Losses from Men at Work and Application to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (*Heating, Piping and Air Conditioning*, June 1931).

Heat and Moisture Losses from the Human Body and Their Relation to Air Conditioning Problems, by F. C. Houghten,

*Reprints available.

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Physical and Physiological Aspects of Air Conditioning, by C. P. Yaglou (*Heating, Piping and Air Conditioning*, January 1932).

Physiological Heat Regulation and the Problem of Humidity, by E. P. Lyon (A. S. H. V. E. TRANSACTIONS, Vol. 27, 1921).

Practical Application of Temperature, Humidity and Air Motion Data to Air Conditioning Problems, by F. C. Houghten, W. W. Teague and W. E. Miller (A. S. H. V. E. TRANSACTIONS, Vol. 33, 1927).

Principles of Air Conditioning (A. S. H. V. E. GUIDE, 1932).

*Refrigeration as Applied to Air Conditioning, by R. W. Waterfill (A. S. H. V. E. TRANSACTIONS, Vol. 34, 1928).

Relation of Standardization to Air Conditioning in the Printing Industry, by W. H. Carrier (*Heating, Piping and Air Conditioning*, April 1931).

The Relation of the Death Rate to the Wet-Bulb Temperature, by Dr. E. V. Hill and J. J. Aeberly (A. S. H. V. E. TRANSACTIONS, Vol. 26, 1920).

Relation of Wet-Bulb Temperature to Health, by O. W. Armspach (A. S. H. V. E. TRANSACTIONS, Vol. 26, 1920).

*Relative Humidity, Its Effect on Comfort and Health, by J. I. Lyle (A. S. H. V. E. TRANSACTIONS, Vol. 18, 1912).

Some Physiological Reactions to High Temperatures and Humidities, by W. J. McConnell and F. C. Houghten (A. S. H. V. E. TRANSACTIONS, Vol. 29, 1923).

*Summer Comfort Zone, Climate and Clothing, by C. P. Yaglou and Philip Drinker (A. S. H. V. E. TRANSACTIONS, Vol. 35, 1929).

Temperature, Humidity and Air Motion Effects in Ventilation, by O. W. Armspach and Margaret Ingels (A. S. H. V. E. TRANSACTIONS, Vol. 28, 1922).

Temperature of Evaporation, by W. H. Carrier (A. S. H. V. E. TRANSACTIONS, Vol. 24, 1918).

Transmission of Radiant Energy Through Glass, by R. A. Miller and L. V. Black (*Heating, Piping and Air Conditioning*, February 1932).

True Significance and Limitations of Effective Temperature Index and Comfort Charts (To be published in *Heating, Piping and Air Conditioning*, June 1932).

Unit Air Conditioners and Coolers (A. S. H. V. E. GUIDE, 1932).

Use of Refrigeration in Air Conditioning, by Lee Nusbaum (A. S. H. V. E. TRANSACTIONS, Vol. 23, 1917).

Value of the Kata Thermometer in Effective Temperature Studies, by Margaret Ingels (A. S. H. V. E. TRANSACTIONS, Vol. 30, 1924).

Work Tests Conducted in Atmospheres of High Temperatures and Various Humidities in Still and Moving Air, by W. J. McConnell and C. P. Yaglou (A. S. H. V. E. TRANSACTIONS, Vol. 31, 1925).

Work Tests Conducted in Atmospheres of Low Temperatures in Still and Moving Air, by W. J. McConnell and C. P. Yaglou (A. S. H. V. E. TRANSACTIONS, Vol. 32, 1926).

*Reprints available.

General Engineering Handbook

McGraw-Hill Book Co., Inc., has recently issued a General Engineering Handbook compiled by C. E. O'Rourke, and a group of associate editors. It contains fundamental engineering data and is divided into four major sections, namely, general civil engineering, mechanical engineering and electrical engineering.

The mechanical engineering section includes a discussion of heating and ventilating by Prof. J. D. Hoffman, past-president of the Society and Professor in charge of Practical Mechanics and Director of the Practical Mechanics Laboratories, Purdue University.

The heating and ventilating section covers heat losses from buildings, heating systems, central station or district heating, boilers, piping, chimneys, heat control and ventilation. The A. S. H. V. E. GUIDE is quoted freely, as are other publications in this field, including Mechanical Equipment of Buildings, Vol. 1, revised edition 1929, by Harding and Willard, Heating and Ventilating, second edition, by Allen and Walker, and various volumes of the A. S. H. V. E. TRANSACTIONS.

Death of George H. Kirk

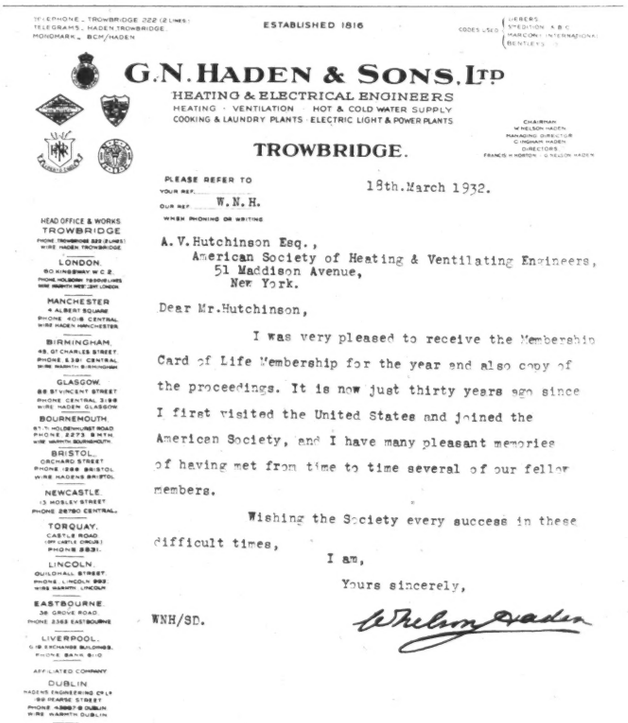
George H. Kirk, a Life Member of the A. S. H. V. E., died March 14, 1932, on board the S. S. Santa Cecilia shortly before entering the Panama Canal on a trip from San Francisco to New Orleans. Mr. Kirk was a well-known heating and ventilating engineer and contractor in Chicago, with offices at 6711 Wentworth Ave.

He was born June 10, 1859 at Nottingham, England, and attended the local preparatory schools.

After serving an apprenticeship with Manlove Alliott Fryer & Co. at Nottingham, he came to this country about 1890. He obtained additional experience with the Burton Stock Car Co. and A. J. Hewling Steam Specialty Co. in Chicago and in 1899 went into business in his own name as a contractor for heating and ventilating apparatus.

He became a member of the Society in 1906 and was granted Life Membership in 1929. He was a member of the Illinois Chapter and of the *Western Society of Engineers*.

The Council and Officers of the Society wish to extend their sincere sympathy to his widow and son who survive him.



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A. V. Hutchinson Esq.,
American Society of Heating & Ventilating Engineers,
51 Maddison Avenue,
New York.

Dear Mr. Hutchinson,

I was very pleased to receive the Membership Card of Life Membership for the year and also copy of the proceedings. It is now just thirty years ago since I first visited the United States and joined the American Society, and I have many pleasant memories of having met from time to time several of our fellow members.

Wishing the Society every success in these difficult times,

I am,

Yours sincerely,

WNH/SD.

Wheldon Haden

Local Chapter Reports

Cleveland

March 18, 1932. The members of the Cleveland Chapter met for dinner in the Jade Room at Fenway Hall preceding the meeting which was attended by several prominent members and officers of the Society. Among these were Pres. F. B. Rowley, Minneapolis, Minn., W. H. Carrier and W. H. Driscoll, past-presidents of the Society, and the secretary, A. V. Hutchinson.

Following the dinner the members and guests attended the Case School Conference on Air Conditioning in the auditorium of the John Hay School, where President Rowley addressed the gathering on the interesting subject of Looking Forward in the Science of Heating and Ventilating, which he illustrated with stereopticon slides.

This conference was sponsored by the Cleveland Engineering Society and the Case School of Science, and during its several days in session attracted a large number of out-of-town visitors.

Illinois

March 14, 1932. One hundred and ten members and guests assembled in the Crystal Room of the Hotel Sherman for the regular monthly meeting of the Illinois Chapter.

Following the announcement of the deaths of W. B. Crawford and G. H. Kirk, it was agreed that H. R. Linn and H. M. Hart prepare appropriate resolutions.

The guests of the evening were then introduced, Pres. F. B. Rowley, University of Minnesota, Prof. G. L. Larson, University of Wisconsin, A. V. Hutchinson, secretary of the Society, and Prof. L. E. Davies, Armour Institute of Technology.

H. P. Reid, research engineer of the Universal Portland Cement Co., was then presented, and with the aid of his staff showed two films, one, Research by High Speed Motion Pictures, being motion pictures of air currents taken by a newly constructed camera capable of making more than 20,000 photographs a second. It also showed a parallel line of smoke passing over air foils and obstacles and through valves and orifices. These pictures were taken by Prof. Shiba, director of Aeronautical Research of Japan; the other was a scientific study of the flight of birds at high and reduced speeds.

L. B. Spafford, editor of *Heating, Piping and Air Conditioning,* made a brief survey on the present depression, its cause and effect, and its relation to the industry.

President Rowley was then introduced by John Howatt. He spoke on Society matters, particularly concerning research, and then described the research work at the University of Minnesota in connection with conductivity of wall materials, which he illustrated with some very interesting slides.

Professor Larson, chairman of the Committee on Research, spoke on the financial problems connected with this work, and its advantages to the members.

Time was then given over to discussion of each speaker's topic, after which a rising vote of thanks was given.

April 14, 1932. The regular monthly meeting of the Illinois Chapter was held in the Crystal Room of the Hotel Sherman, Chicago, and was well attended.

The committee appointed at the last meeting, consisting of H. M. Hart and H. R. Linn, to prepare resolutions in the memory of G. H. Kirk and W. B. Crawford, reported through the Secretary, who read the following resolutions:

WHEREAS, it has pleased Almighty God in His all wise providence to remove from the roll of our Society to the roll of those who have passed on to their Heavenly Reward, our cherished members, George H. Kirk and Wm. B. Crawford, and

WHEREAS, by their passing we shall all miss their comradeship, their helpful advice and their loyal cooperation in the affairs of the Society,

THEREFORE, BE IT RESOLVED, that in respect to their memories we, the Illinois Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, pause in our deliberations, and that this resolution be spread upon the minutes of the Society, and that a copy of this resolution be sent to the families of the departed members.

These resolutions met with unanimous approval.

The report of the Nominating Committee proposed the following: *President,* J. H. O'Brien; *Vice President,* C. W. DeLand; *Secretary,* J. J. Hayes; *Treasurer,* J. H. Milliken; *Board of Governors,* J. J. Aeberly, R. E. Hattis and G. H. Blanding.

The picture From Coal to Electricity was shown through the courtesy of Stone & Webster Corp., with G. H. Blanding acting as interpreter.

R. E. Hattis led a short discussion on the Hartford return connection to boilers.

H. J. Schweim, chief engineer of the Gypsum Association, discussed the latest developments in house insulation. He described briefly each of the several kinds and types of insulation.

M. A. Smith, engineering sales manager, U. S. Gypsum Co., was the guest speaker of the evening. He discussed the subject Architectural Acoustics and the Isolation of Machinery Noises from Structures, which was exceptionally interesting.

Massachusetts

March 21, 1932. Forty members of the Massachusetts Chapter gathered for a luncheon meeting in a private dining room of Durgin Park & Co. in Boston.

Edwin Q. Cole, a member of the Chapter, addressed those present on The Thermal Theory of Ventilation and described briefly the history of ventilating theories from the past up to present day practices. He urged the adoption of practice minimizing the quantity of air delivered, stressing the fact that ventilation today within a schoolroom or the like is a matter of cooling with air, rather than of warming the occupied room by air introduction.

Following Mr. Cole's presentation, a lively discussion took place and it is indicated that this will be resumed at an evening meeting in the near future.

Western Michigan

March 21, 1932. A dinner and meeting of the Western Michigan Chapter was held at the Rowe Hotel, Grand Rapids, with an attendance of over 35. The regular meeting date of the chapter had been changed in order that John F. Hale, Past-President of the Society, could be present to give a talk on his 40 years of experience in the heating and ventilating industry.

After dinner the business of the meeting was conducted by Pres. O. D. Marshall, who announced that the Board of Governors had selected a nominating committee consisting of C. H. Morton, Cornelius Lammers, and W. J. Temple. This committee is to report at the next meeting and submit their recommendations as to officers for the year 1932-1933.

President Marshall then introduced Mr. Hale, whose talk was very much enjoyed and consisted of tales of his experience in the heating field. He gave interesting examples of the progress which has been made in that time and offered predictions as to changes in the future. An interesting discussion was held at the conclusion of Mr. Hale's address.

Members of the Chapter are looking forward to the annual May meeting, when new officers are to be elected. The Entertainment Committee promises a good time for everyone.

Michigan

March 14, 1932. Thomas Chester was the speaker of the evening at the March meeting of the Michigan Chapter, held at the Detroit Engineering Society. About 40 members and guests were present.

Mr. Chester's talk on Air Conditioning was well illustrated by models and sketches and was enjoyed by all present. An interesting discussion followed its presentation.

A motion was made and seconded to obtain further details regarding membership in the Associated Technical Societies.

William G. Boales was appointed to handle the arrangements for the Detroit members who plan to attend the Semi-Annual Meeting of the Society in Milwaukee in June.

An invitation was extended to the Chapter to attend the meeting of the *American Society of Refrigerating Engineers*, March 21, 1932.

The meeting was adjourned at 9:30 o'clock.

Minnesota

March 14, 1932. The Minnesota Chapter held its regular monthly meeting in the Minnesota Union at the University of Minnesota, with an attendance of 48 members and guests, and Pres. H. E. Gerrish presiding.

Following the dinner, the meeting was called to order and the minutes of the preceding meeting were read and approved.

Albert Buenger, chairman of the Membership Committee, reported on the results of the membership drive and the possibilities for obtaining new members.

A. J. Huch, chairman of the Meetings Committee, then reported on the plans for the April and May meetings.

President Gerrish then introduced the guest speaker of the evening, Arthur Hardgrave, president of the City Ice Co. of Kansas City, who addressed the meeting on the Use of Ice for Space Cooling, which he very ably presented and included some very interesting facts on its development, method of application and figures on installation.

After much discussion which included questions on safety, cost of maintenance, space requirements, and method of control, a rising vote of thanks was extended to Mr. Hardgrave.

Western New York

March 14, 1932. Pres. M. C. Beman presided at the March meeting of the Western New York Chapter, which was attended by 35 members and guests.

President Beman repeated his pledge to further the interest of the Chapter and asked the loyal support of all, announcing at this time the appointment of new committees, who were functioning very well. He then announced he would appoint a committee to investigate the Chapter affiliation with the Engineering Society of Buffalo and report at the next meeting with recommendations.

The speaker of the evening, A. G. Smith, general sales manager of the Buffalo General Electric Co., was introduced, and he discussed intelligently the electrical development of the Niagara Frontier. He also traced the development of A. C. current from 35 to 40 years ago, having its start at 25 cycle due to hydro development at that time and the fact that only 25 cycle rotary converters were available. The development was originally for industrial use and supplanted D. C., in fact, Buffalo was the first city to obtain electrical power for industrial purposes.

Mr. Smith then spoke of the vast distributing system both overhead and underground and the precautions taken to insure dependability, all of the substations working automatically.

A lengthy discussion followed Mr. Smith's talk which was an enjoyable and instructive presentation.

April 12, 1932. At the April meeting the Western New York Chapter was host to the President and Secretary of the Society F. B. Rowley and A. V. Hutchinson.

Following the usual routine business and listening to Mr. Mahoney's report of his committee's decision to continue the affiliation with the Engineering Society of Buffalo, Pres. M. C. Beman, asked L. A. Harding, past-president, to introduce President Rowley, who addressed the Chapter on Looking Forward in the Science of Heating and Ventilating.

President Rowley traced the history of the heating and ventilating industry from cave man days to the present state of high development. He also brought out the part played by the Research Bureau of the Society and what could be expected in the future. With the aid of slides he gave very instructive data and information which showed the particular prominence that insulation played in efforts to heat or cool buildings.

A lively discussion led by Mr. Harding and Mr. Cherry followed President Rowley's talk and then Secretary Hutchinson was asked to tell the Chapter any new happenings in the Society. Mr. Hutchinson stated that their revised schedule of expenses was being held to and he also promised a new booklet describing the advantages of membership in the Society which would be an aid to all membership drives.

The members were urged to go to Milwaukee in June for the Semi-Annual Meeting, as the Milwaukee Chapter was planning on more than one pleasant surprise to entertain the members.

A rising vote of thanks to the President and Secretary closed this most interesting and intstructive meeting.

Pittsburgh

March 17, 1932. The March meeting of the Pittsburgh Chapter of the American Society of Heating and Ventilating Engineers was held in the Grill Room of Hotel Mayfair, with 50 members and guests present. During the course of the dinner, S. H. Harper surprised and entertained the members and guests by calling F. C. McIntosh on the telephone and letting everyone listen in on the conversation via a loudspeaker, which was thoroughly enjoyed.

Pres. R. B. Stanger called the meeting to order, followed by the reading of the minutes of the February meeting, which were approved as read.

F. C. McIntosh, chairman of the Program and Publicity Committee, made several announcements regarding the speakers at the meetings to come.

Mr. McIntosh then introduced W. H. Driscoll, vice-president of Thompson-Starrett Co., New York, and a past-president of the Society, who gave an excellent talk on the development and accomplishments of heating and ventilation, with special reference to Society codes. Mr. Driscoll told about some of the heating and ventilating jobs on which he has worked, including the remodeling of the Metropolitan Opera House in New York, and the tremendous engineering problems encountered in clearing a site for the new Waldorf Astoria Hotel. He traced the development of our old problem of open window versus mechanical ventilation. Mr. Driscoll also stated that it is very difficult to formulate a perfect code which will provide for all possible developments and not restrict future ideas. He then mentioned some of the late determinations of the A. S. H. V. E. Research Laboratory and of the Harvard School of Public Health, which is cooperating with the Research Laboratory. He also brought out the value of membership in the Society, and urged members to attend its conventions.

After numerous questions were raised by his listeners, Mr. Driscoll was tendered a rising vote of thanks in appreciation of his talk.

St. Louis

March 16, 1932. At the March meeting of the St. Louis Chapter 60 members and guests assembled at the Roosevelt Hotel, with Pres. J. M. Foster as the presiding officer.

Following the reports from the various Committee chairmen S. G. Hallett, chairman of the Education Committee, introduced Professor Turner of the David Rankin Trade School, who advised the Chapter of the progress being made in their heating and ventilating work and thanked the Chapter for their cooperation. This course was started in 1929 and to date 63 members have enrolled. He suggested that the Chapter have one of their regular meetings at the School and meet with their class on heating and ventilating, as the St. Louis Chapter was primarily responsible for the David Rankin Trade School including the course of heating and ventilating in their curriculum.

A. S. Langsdorf, Dean of the School of Engineering at Washington University, was then introduced, and he expressed his pleasure in being able to meet with the Chapter and to hear Professor Rowley. He further requested, that the Code Committee consider the question of proper flues for heating plants in order to properly consume and carry off smoke which is in line with his work on Smoke Abatement.

President Foster then turned the meeting over to Paul Sodemann, chairman of the Program Committee, who then introduced Roscoe Nunn, Senior Meteorologist of the St. Louis Weather Bureau. Mr. Nunn described the scientific method of making weather forecasts and the published charts of the atmospheric conditions of St. Louis.

Mr. Sodemann then called on A. V. Hutchinson, secretary of the Society, who spoke on the financial condition of the Society, as well as the need of new members, who are interested in and allied with the heating and ventilating industry.

The guest speaker of the evening, F. B. Rowley, president of the Society, was then introduced. President Rowley presented a very interesting paper entitled Looking Forward in the Science of Heating and Ventilating. He explained in detail the method used at the University of Minnesota in determining the coefficients of heat transmission through various types of building walls and partitions. This work is being carried on with the assistance of the A. S. H. V. E. Research Laboratory. His talk was accompanied by stereopticon pictures, covering the various apparatus used in this test together with the types of walls and results obtained, which govern the transmission coefficient.

Many questions were answered by President Rowley covering test problems and application of his work. A rising vote of thanks was given to President Rowley and Mr. Nunn for the splendid papers they presented.

Southern California

March 14, 1932. The Southern California Chapter held a meeting at the Engineers' Club, Los Angeles, at which 67 members and guests were present. Many of the guests were members of the *American Society of Refrigerating Engineers* and the *American Institute of Architects.*

After dinner the meeting was called to order by President Franklin R. Winch and a short business discussion took place in which approval was given by the Chapter to the amendments to the Constitution.

President Winch turned the meeting over to Ralph E. Phillips, consulting engineer, who presented a paper covering the general phases of Air Conditioning and its Relation to Public Buildings. Mr. Phillips' talk was illustrated with slides and was very interesting. At its conclusion he introduced Donald T. Robbins, his assistant, who presented a more technical paper on the same fundamental subject. The meeting was then opened for discussion in which all those present were invited to join.

During the meeting a telegram was read from L. H. Polderman, vice-president of the Chapter and chairman of the Program Committee, who was in New York City. Mr. Polderman expressed his regrets at being unable to attend the meeting and promised a very interesting program for April.

The meeting was adjourned at 9:30.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 19 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some members by May 14, 1932, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ADLAM, T. NAPIER, Chief Engr., Sarco Co., New York, N. Y.	E. J. Ritchie R. W. Cumming	
BARKER, HUGH PARSLOVE, President, Barker, Young & Co., Ltd., Westminster, England.	A. H. Barker Percy Nicholls	F. D. Mensing C. V. Haynes
BERRY, FEROL WAYNE, Hall-Neal Furnace Co., Indianapolis, Ind.	J. H. Van Alsburg J. C. Miles	P. J. Marschall M. I. Levy

BRAY, HARRY FRANKLIN, Sales Engr., Excelsior Stove & Mfg. Co., Quincy, Ill.	J. M. Foster C. R. Davis	P. W. Sodemann O. H. Wolff
GOEZ, WALTER E., President, Old Orchard Sheet Metal Works, Webster Groves, Mo.	K. S. Wallace R. M. Rosebrough	J. M. Foster F. J. McMorran
LANDAUER, LEO L., C. L. Kribs, Jr., Cons. Engr., Dallas, Texas.	W. H. Moler T. M. Cunningham	F. C. Hersh O. E. Gammill, Jr.
LOWE, HOWARD HENRY, Student, Univ. of Minnesota, Minneapolis, Minn.	F. B. Rowley A. B. Algren	D. M. Forfar J. V. Martenis
LYONS, CORNELIUS J., Nash Engrg. Co., South Norwalk, Conn.	H. M. Wylie R. H. Carpenter	A. D. Harvey E. A. Mead
MAEHLING, LEON S., Equitable Gas Co., Pittsburgh, Pa.	P. A. Edwards E. C. Evans	H. B. Orr T. M. Dugan
MOODIE, DWIGHT L., Sales Engr., A. K. Howell Co., Inc., St. Louis, Mo.	G. A. Helwig H. C. Murphy	J. W. Cooper K. S. Wallace
REED, PAUL LEONARD, Editor, Warm Air Heating, St. Louis, Mo.	E. B. Evleth E. B. Langenberg	G. W. F. Myers G. A. Helwig
SHEPARD, EDWARD C., Shepard Engrg. Co., New York, N. Y.	E. J. Ritchie R. W. Cumming	H. W. Hochuli T. M. Kellogg
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WEBER, WILLIAM D., District Sales Mgr., Carrier-Lyle Corp., Cincinnati, Ohio.	H. A. Thornburg J. E. True	G. G. Schmidt C. A. Rydell
WILSON, WILLIAM HENRY, Pullman Car & Mfg. Corp., Chicago, Ill.	H. R. Linn C. W. DeLand	W. H. Chenoweth C. W. Johnson

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

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GREENBURG, LEONARD, Assoc. Dir. of Research, Pierce Foundation, New Haven, Conn.

MCGONAGLE, ARTHUR, Consulting Engr., Arthur McGonagle, Pittsburgh, Pa.

MEYER, FRANK L., Treas., Meyer Furnace Co., Peoria, Ill. (*Advancement*)

RAY, LEWIS BANKS, Manager, Ray Engrg. Co., Newark, N. J.

STEVENSON, ALEXANDER R., JR., Staff Asst. to Vice-Pres., General Electric Co., Schenectady, N. Y.

TENNEY, DWIGHT, Chief Engr., Booth Engrg. Co., Ltd., Newark, N. J.

WINSLOW, CHARLES-EDWARD A., Prof. of Public Health, Yale School of Medicine, New Haven, Conn.

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PRYIBIL, PAUL LESTER, Hucker-Pryibil Co., Philadelphia, Pa.

WEBER, C. A. M., Manager, Motored Appliance Engrg. Dept., Westinghouse Elec. & Mfg. Co., Springfield, Mass.

JUNIOR

HALL, JOHN R., U. S. Blower & Heater Co., Minneapolis, Minn.

Heating · Piping and Air Conditioning

EDITORIALS

» » Patronage of the Baltimore & Ohio's air-conditioned trains has been "gratifying," according to Daniel Willard, president of the B. & O., in his annual report issued a few days ago. According to Mr. Willard, with the experience already gained and with further study it is planned to expand this service.

"To sustain and invite long distance traffic," says Mr. Willard in his report, "experiments were begun a few years ago to develop an even greater degree of comfort for patrons and it was the privilege of the company to install and operate the first completely air-conditioned train in the history of railroading. The innovation was well received by the traveling public and plans were perfected whereby a second train was equipped and put in operation."

Almost invariably, where air conditioning has been used as a means of attracting the public and providing it with comfort, it has proved commercially successful. The case of the movie theaters, where air conditioning deserves most of the credit for successful summer operation, is particularly striking. Restaurants and hotels have also found in air conditioning the answer to many problems and in several office buildings provisions for maintaining comfortable atmospheric conditions have simplified the rental of space and resulted in other advantages.

In a myriad of industrial processes air conditioning is essential; apparently air conditioning for human comfort is rapidly becoming no less essential.

» » Data on the actual operation of air conditioning, heating and piping systems and equipment are of great value to engineers in predicting results that may be obtained and in making available a standard for comparison. Obviously, such data must be reliable to be of service; in addition, much of the effectiveness and help that operating data can give is lost if the records are incomplete.

Records of performance kept by operating engineers are of particular interest, representing as they do actual operation. While information obtained in the laboratory and by means of tests is of unquestioned value, that which may be learned in operation and under operating conditions is a valuable check and is looked upon with high regard.

Much credit is due the operating engineer who keeps careful records of the operation of the systems under his charge, particularly if his records are in such form so that all of the factors which influence the recorded performance may be understood. Completeness of performance data (within practical and economic limits) would seem to be something to be striven for as by recording all of the factors which influence performance, others may know exactly what the data represent and if necessary allow for those factors which differ in applying the data to another problem.

» » "Telemeter" is a generic term for a rapidly increasing group of instruments for long-distance operations. They are of great assistance in many applications. In an oil refinery, for instance, a still operator wishes to close a valve which is located a mile away. The operator of the still can turn a wheel in the control house and manually operate the distant valve. Over his head is an indicating instrument that shows the position of the valve with respect to its degree of opening at all times.

In an office building an engineer below the ground level turns a switch and reads the temperature in an office 1,000 feet above the street; he turns the switch further and successively reads temperatures at many other points in the building.

In a hydro-electric station the operator looks at an instrument and notes the water level in a reservoir two miles up the mountain.

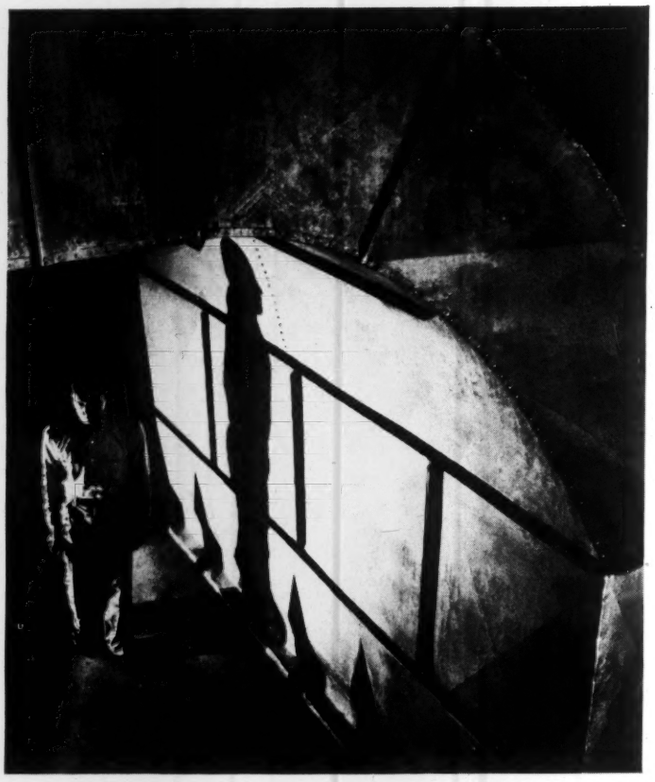
A district steam service load dispatcher turns a switch in a central plant and successively reads on an instrument before him the rates at which steam is respectively flowing in a number of feeders from a distribution main.

An engineer in Chicago is planning to control temperatures in a group of buildings by radio from a central point.

An operator of an irrigation works controls the opening of a remote water gate, and from an instrument close at hand checks the movement of the distant barrier.

Centralization of control means unification and harmony of effort in operation. The use of telemetering and telecontrol devices will often save time, lost motion, misunderstanding, needless losses.

"Men make machines" — and men must operate them. In preparing for tomorrow building up a strong personnel is essential



PREPARING FOR TOMORROW

If you listen carefully to Nature's symphony of sounds from Niagara Falls you can at length detect one dominant note. While business apathy can scarcely be compared to a symphony, it is true that if one listens carefully he can also detect in business activities a dominant note. That note, which is reflected from organizations large and small, is "Prepare for tomorrow—Prepare for tomorrow." It is pointed out that in preparing for tomorrow this is a good time to procure the services of engineers. Never before were so many experienced men available,—men who can help to lay the foundation for tomorrow's business.

A free selective service is being maintained by practically every engineering society. Utilization of these services will be of advantage.

Removal of Moisture from Precipitates—Drying Zinc Stearate

By Malcolm Tomlinson*

REMOVAL of moisture from many precipitates resulting from chemical reactions often involves problems never encountered in other drying fields. Zinc stearate or $Zn\ (C_{18}H_{35}O_2)_2$ furnishes a very good illustration of some of these problems. In its commercial form it is mixed with 13 to 15½ per cent of zinc oxide and some zinc palmitate. It is a fine, white, soft and bulky powder insoluble in water, alcohol, and ether and is used as a dusting powder to relieve sunburn, to prevent chafing, to keep the skin soft and smooth and to prevent the irritating effects of excessive perspiration. It may be formed through the reaction of sodium carbonate and stearic acid but is generally made through the mutual decomposition of 100 parts of zinc acetate and 279 parts of sodium stearate. The precipitate is washed thoroughly in water, dried and then ground to the powder form.

The selection of a drying method depends upon the value of the iodine number in the finished product. If dried in a current of hydrogen on a steam bath or in an open flask the iodine number is unchanged but the use of an open oven changes the iodine number and is likely also to change the acid and the saponification numbers. In the discussion which follows it is assumed that the iodine number is not important.

It is necessary to know the physical characteristics of any product before one can proceed with a drying program. With a chemical the important characteristics are specific heat, fusion point and decomposition point. At times the molecular weight may also prove helpful in throwing additional light on the substance.

Although the atomic weight of zinc stearate (632.1) is easily found it is practically impossible to locate the desired temperatures and specific heat in any physical or chemical tables printed in the English language. Nevertheless, decomposition occurs at a higher temperature than fusion and is not a factor in drying this material. Furthermore zinc stearate may be dried, under atmospheric pressure, in a steam bath in a current of hydrogen. Therefore a drying temperature of 212 F is safe in an open system where the air is in the right condition. Again, the mean specific heats of many chemicals range from 0.2 to 0.3 Btu while that of calcium carbonate is 0.21. Since stearate and oleate salts, which are derivatives of fats, are lower in specific heat than most chemical compounds it is safe to use a value of 0.2 for zinc stearate in the low-temperature range at which drying occurs.

In drying zinc stearate a current of air is desirable to decrease the drying period. This current must be quite slow or the precipitate will be blown out of the tank. When metal containers are used this air should have a relative humidity above 35 per cent to prevent trouble from static electricity; otherwise the fine particles will adhere to the sides and bottom. Of course some form of agitation or stirring must be employed.

For a practical example consider a metal tank 5½ ft. in diameter which contains 80 per cent moist zinc stearate to the depth of one foot. Assume a drying temperature of 150 F. The volume of the moist zinc stearate will be 23.76 cu. ft. Assuming 150 lb. per cu. ft. of dry zinc stearate and that it occupies the same volume as the moist we have:

150 x 23.76	or	3564 lb. of zinc stearate-dry
150 x 23.76 x 0.8	or	2851 lb. of water
Total		6415 lb. of material.

The heat required to heat this material will be:

3564 x 0.2 x (150–70)	or	57,024 Btu per hr. for zinc stearate-dry
2851 x 1.0 x (150–70)	or	228,080 Btu per hr. for the water in the stearate
Total		285,104 Btu per hr.

If steam at 15-lb. pressure be used to heat this material the amount of steam required would be:

$$\frac{285{,}104}{947\ \text{(latent heat)}} \quad \text{or 301 lb. per hr.}$$

These figures are based on a room temperature of 70 F.

These data do not take into account the heat required to raise the temperature of the tank itself to 150 F. The latter would no doubt require at least 50 more pounds of steam each hour.

Losses in the transmission of the heat from the steam coils to the material and from the tank itself and the material to the surrounding air must also be figured. The amount of extra heat required will, of course, depend upon the design of the tank and its insulation. These items can easily increase the steam requirements to double the 350-lb. quantity.

*Consulting engineer, Urbana, Ill.

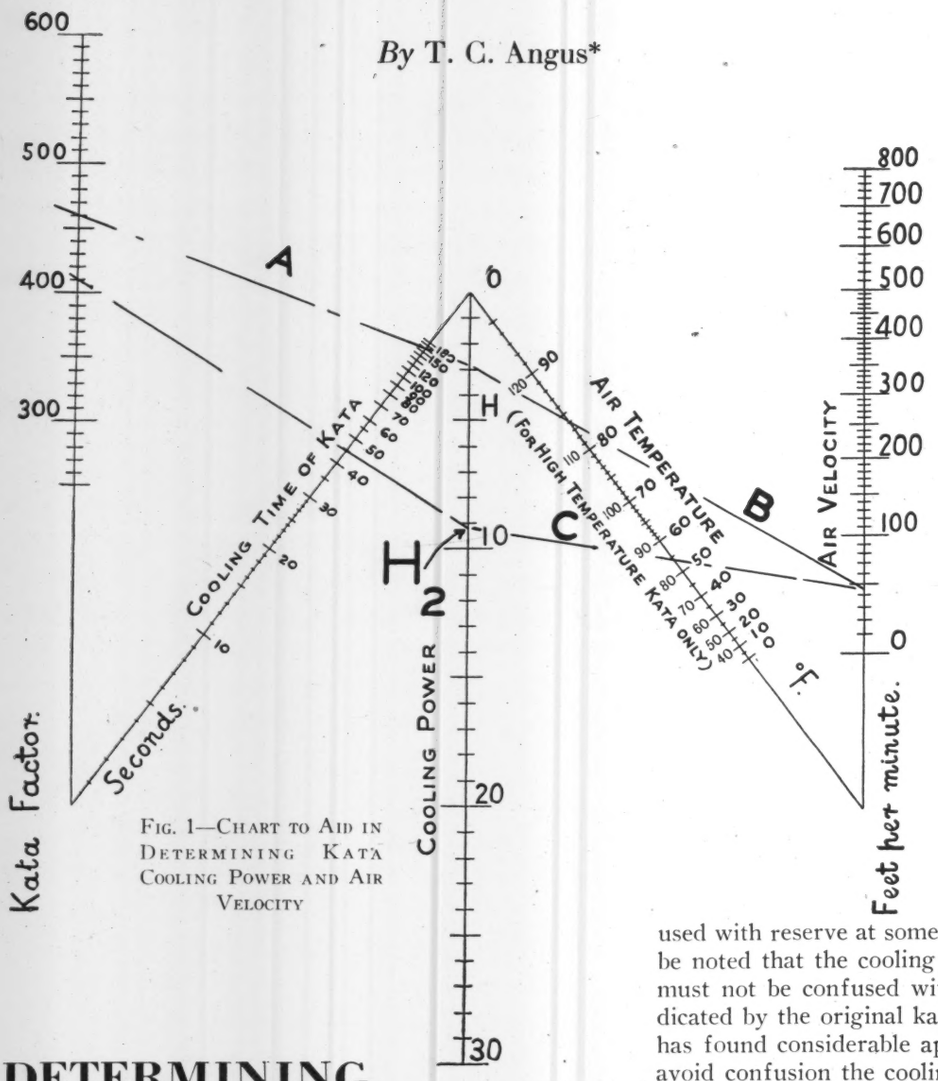


FIG. 1—CHART TO AID IN DETERMINING KATA COOLING POWER AND AIR VELOCITY

DETERMINING AIR VELOCITY

With High-Temperature Kata

By T. C. Angus*

DETERMINATION of the effective temperature thermal index requires the air velocity to be found at the point under consideration, as well as the dry-bulb and wet-bulb temperatures. Yaglou[1] has recommended the use of kata thermometers as a convenient and reasonably accurate means to determine this velocity, but the drawback to using the original kata for this purpose is that when the dry-bulb temperature is above 75 F (and particularly when in the neighborhood of 90 F, temperatures sometimes met with in industrial buildings in this country) the necessary observations take a long time because of the slow rate of cooling of the kata bulb, whose mean temperature of 97.5 F is intended to approximate that of the exposed human skin.

Leonard Hill's new instrument[2], the high temperature or "blue" kata, overcomes this difficulty by working at a mean temperature 30 F higher than that of the original kata, which rise in temperature not only causes the bulb to cool more quickly under given conditions but also allows the instrument to be used as an anemometer in air streams hotter than 95 F, where the original instrument could not be used at all. It has been shown[1] that the following formula holds good for both the old and new instruments:

$$V = 197 \left(8 \frac{H/\theta - 0.15}{1.85 - H/\theta} \right)^{5/4}$$

Where V = air velocity in ft. per min.

θ or θ_2 = temperature difference (F) between mean bulb temperature and air.

$\theta = 97.5 - t$ (low temperature kata).

$\theta_2 = 127.5 - t$ ("blue" temperature kata).

H (or H_2) = cooling power in milicalories per sq. cm./sec. of the kata bulb.

t = temp. of air (F).

The above formula has been verified by careful experiments up to velocities of 1,060 ft. per min. and may be used with reserve at somewhat higher velocities. It must be noted that the cooling power shown by the blue kata must not be confused with H, the cooling power as indicated by the original kata—an index of comfort which has found considerable application in Great Britain. To avoid confusion the cooling power indicated by the new instrument is referred to as H_2; for a similar reason the color of the spirit in its bulb has been changed.

The left-hand half of the nomograph (Fig. 1) is intended to save the small calculation needed to find the kata cooling power H or H_2 from the time taken by the instrument to cool, and is equally applicable to either the original or the new instrument. Thus if the factor (a value peculiar to the individual instrument and marked on the stem by the maker) is 460 and the instrument (one of the original type) cools in 160 seconds, the cooling power H is the factor divided by the time or 2.9 (nearly); as shown by line A. To find the air velocity past the kata it is necessary to know the air temperature. Suppose this to be 84 F, a line B taken from 2.9 on H through 84 F on the air-temperature scale will indicate a velocity of 45 ft per min. If now a blue kata with a factor assumed to be 410 is used under the same conditions, it will be found to cool in only 45 seconds (instead of over 2½ minutes), and will give an H_2 of 9.2, from which value a line C through the air temperature on the *high-temperature kata scale* will indicate the same air velocity. As has been shown in a recent issue of *Engineering*[3] low values of H, ordinary kata standard, can easily be deduced from readings of the blue kata by the use of this chart.

* School of Public Health, Harvard University, Boston, Mass.

[1] Yaglou, C. P., "The Thermal Index of Atmospheric Conditions and its Application to Sedentary and to Industrial Life," *Journal of Industrial Hygiene*, Vol. VIII, No. 1, January, 1926.

[2] Angus, T. C., Hill, L., and Soper, H. E., "A New Kata Thermometer for Hot Atmospheres and a Simplified Method for Computing," *Journal of Industrial Hygiene*, Vol. 12, February, 1930.

[3] Angus, T. C., "A New Kata-thermometer," *Engineering*, Vol. CXXXIII, No. 3541; p. 281, March 4, 1932.

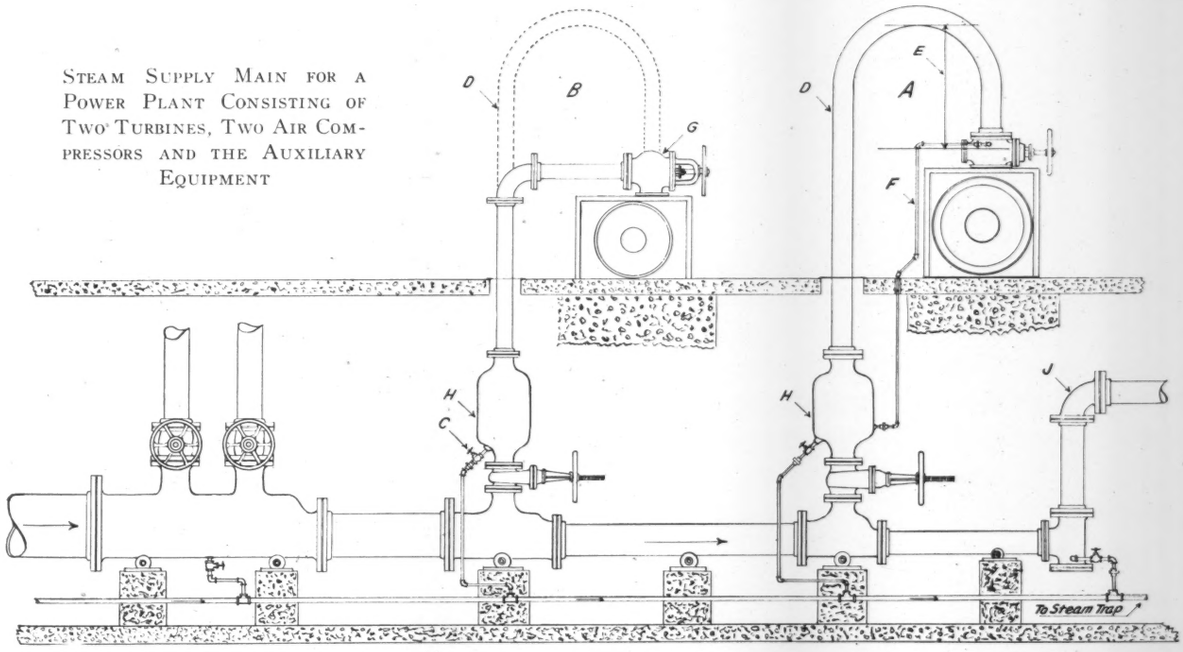
On the Job

. . . a department devoted to short, practical articles on the installation, operation and maintenance of air conditioning, heating and piping equipment . . . . . .

Operating Steam Mains

By W. H. Wilson

SUCCESSFUL operation, care and maintenance of large steam mains depends upon careful installation of supports, proper alignment, adequate removal of condensation, provision for expansion and contraction and the use of material that is suitable for the service. Drain valves, gage piping and small pipe connections should be of material that is of the proper strength and conform to requirements, as should the larger piping and fittings.



STEAM SUPPLY MAIN FOR A POWER PLANT CONSISTING OF TWO TURBINES, TWO AIR COMPRESSORS AND THE AUXILIARY EQUIPMENT

Fig. 1 shows a steam supply main for a power plant, consisting of two steam turbines, two air compressors, the necessary auxiliary equipment and a steam supply line leading to other sections of the plant.

The steam supply main shown is located in the basement of the building. Tees of the eccentric pattern, the outlets placed upward, are used to bring the different size pipes to the same drainage level. The supply to the several power units rises vertically from the main and leads to the units on the main floor. When this main was installed, a 1½-in. drainage line for the condensation was installed, parallel to and lower than the steam main, with drip connections at several points leading to a steam trap.

After being in daily use for a number of years, with steam at 180-lb. working pressure, the following has been experienced:

At one time during regular operation the steam supply failed to maintain the required pressure. As an aid to getting the steam pressure back to normal, the larger of the two air compressors (farther from the steam supply) was shut down. Immediately after this unit was shut down and before the steam pressure had raised so as to be noticeable on the gage, the bonnet blew off drip valve *C* at the steam separator on the other unit. While the cause may be a matter of opinion, it was attributed to the fact that when the large machine was shut down the flow of steam was suddenly stopped and caused the condensation in the trap line at that point to flow backward and deliver a water-hammer blow which affected the valve *C*. After this occurred the drip line

for delivering all of the condensation to one trap was removed and an individual trap was provided for each drip connection.

Attention is called to the pipe bends *D* on the steam supply to the air compressors; a water pocket is formed when the steam supply is shut off at the throttle valve. This causes the water of condensation to collect in the pipe bend to the height of *E*, causing temperature changes which affect the gaskets in the throttle valve flanged joints allowing water to seep out and giving rise to deterioration of the gasket material.

This trouble was overcome by installing a separate drip line *F* as an equalizing pipe, which permits the condensation to flow back to the steam main.

The pipe connection on the other machine *B*, where the angle valve *G* is used, does not allow condensation to accumulate. Opinions differ as to whether the pressure side of a disc throttle valve should be placed toward the steam supply main or toward the engine. At any rate the angle valve, in this case, can be faced to conform to either method.

On one occasion a fitting was broken at *J* by a quantity of water in the steam being carried over from the boilers, due to improper regulation at the time a steam supply branch line was turned on in another section of the plant. This caused a strong flow through the main and a water hammer blow at the end of the main, which broke the elbow *J*. This supports the point of view that steam mains should be provided with water pockets or reservoirs to receive large slugs of water that are likely to be carried into the mains and overload the traps. A suitable reservoir or pocket will receive the water and hold it until the steam traps can take care of it in the usual way.

Controlling a Water Heater

By E. D. Rogers*

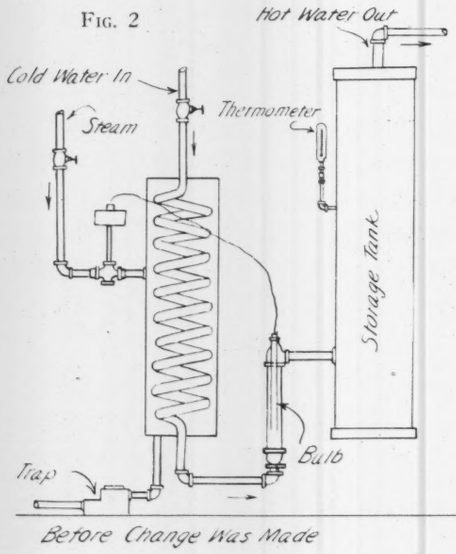
IMPROPER application of temperature controls may result in unsafe conditions. A heater and storage tank were installed in a factory to supply warm water to a number of shower heads in the employe's wash room. A temperature regulator was installed but the person making the installation had something to learn and a number of men were severely scalded. The temperature regulator was said to be at fault and so the manufacturer's service man was called in.

Fig. 2 shows the job as installed. The temperature-regulating valve was properly installed, but its bulb was so placed that there was no circulation of water over it unless water was being drawn from the storage heater; this water was only drawn at intervals. During idle moments the water surrounding the bulb became cooled and the thermostat opened the steam valve and held it open during this idle period. Consequently, the water in the heater reached too high a temperature.

The piping layout was re-arranged as shown in Fig. 3. The cold water supply line was connected to the bottom of the heater. The thermostat bulb was placed in an enlarged section of the hot-water line going to the top of the storage heater. A return line with a check valve was run from the bottom of the storage tank and connected to the bottom of the heater as shown. The check valve prevents cold water entering the storage tank without first going through the heater. It can be seen that a continuous circulation of water is maintained in the heater and tank and that the thermostat bulb is immersed in the circulating water, giving accurate control of the water temperature.

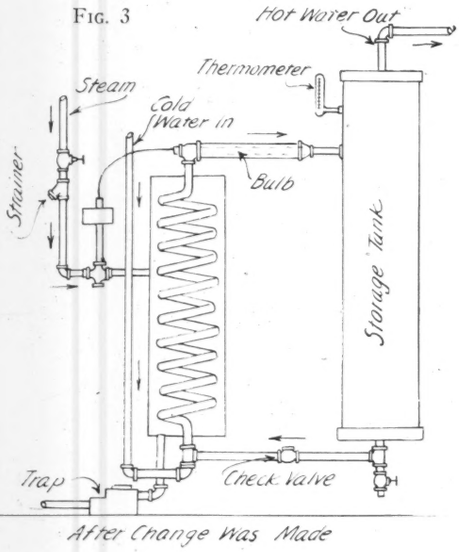
* Heating Sales Division, Fulton Sylphon Co., Knoxville, Tenn.

FIG. 2



Before Change Was Made

FIG. 3



After Change Was Made

Organization for Industrial Piping Installations

BY applying modern production methods to the installation of welded industrial piping, time and money are saved. The system used by one firm with considerable success is described here.

Their whole organization hinges on expediting the work of the erection force. Fig. 4 illustrates the general flow of authoritative information and material from the beginning of design to the final erection of the pipe in the field. While this follows in general the customary procedure of past years, it shows definitely the steps taken to make the various departments responsible for only their own work. This is the first step toward freeing the foreman and mechanics of the erection crew of any but assembly work.

The design department executes the general drawings and job sketches. This department also draws up a *Bill of Material* for each individual line from the general drawings and sends a summary of all bills of material to the purchasing department, which, in turn, orders the material. Materials are received by the receiving department and checked off on the bills of material. Then when all material for an individual line is on hand the route clerk, to whom the job sketches have been

turned over, posts the individual line on a *Line List*. This indicates that all items for the line are on hand and that the erection crew can start work on the line posted. Materials are carried to the field location or welding shop, as the case may be, by the labor gang, and the pipe is fabricated, erected, tested, insulated and painted. Finally all costs are taken by the accounting department and allocated.

Considering the general working drawings, in order to have no delays in the field through inaccuracies, it is considered essential to execute them on a fairly large scale and have them carefully checked before releasing them to the field forces. Clearances and interferences must be established correctly, particularly if the lines are to be insulated. It is essential to give an identifying number to each individual line and to mark it in several places on the drawing. This line number is carried on job sketches, bills of material and actual materials for each line. This simplifies all operations from the preparation of job sketches to the determination of costs.

Job sketches are prepared in the drafting room on calculated dimensions from the general drawings. This is a decided economy, as sketches made up in the field by the assembly men are sometimes found to be inaccurate and cause loss of time. By utilizing job sketches before actual assembly has started, all of the piping can be fabricated well in advance. All information required on the job sketch, such as sketch number, line number, date, building, charge order, and department is of importance in keeping accurate records. The details are drawn to correct scale and dimension, and carry all required data. Care is taken to mark field connections as such, so that adjustments can be made as required in the field while the pipe is being erected.

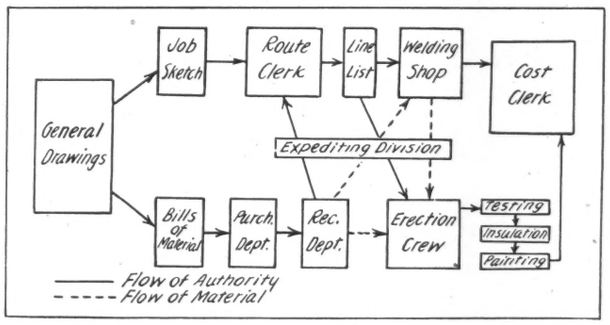
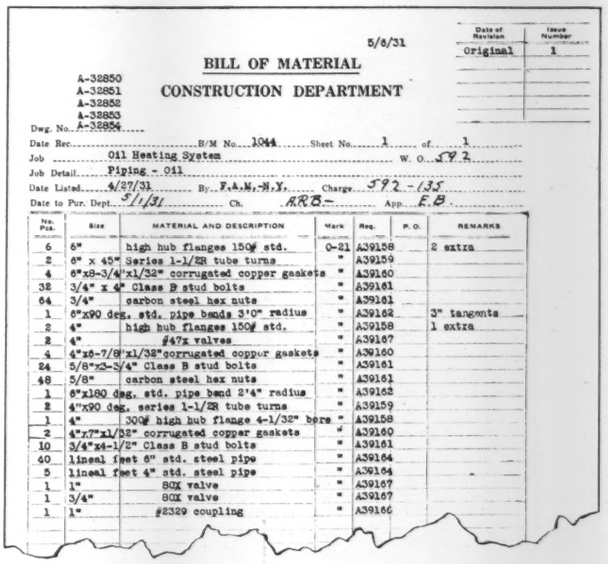


FIG. 4—OPERATING AUTHORITY AND FLOW OF MATERIALS ARE ORGANIZED IN ADVANCE

Bills of material are made up from the general working drawings on standard forms. The material take-off is done by the same group that prepared the working drawings, and include every item down to the bolts and gaskets required for valves and flanges that are necessary for the completion of the line which each bill of material covers. This is a time-saving move. Because of the designer's familiarity with the details, and because he has all the catalog references on hand, the net result is low unit cost with large output. To wait and take off material on the job is expensive. The time-saving factor permits a longer period in which to obtain prices, and permits items to be summarized and purchased in bulk, which in turn means both greater purchase discount and lower transportation charges.



5/6/31

BILL OF MATERIAL

CONSTRUCTION DEPARTMENT

Date of Revision	Issue Number
Original	1

A-32850
A-32851
A-32852
A-32853
A-32854

Dwg. No.

Date Rec. B/M No. 1044 Sheet No. 1 of 1

Job Oil Heating System W. O. 592

Job Detail Piping - Oil

Date Listed 4/27/31 By F.A.M.-H.Y. Charge 592 - 135

Date to Pur. Dept. 5/1/31 Ch. ARB- App. E.B

No. Pcs.	Size	MATERIAL AND DESCRIPTION	Mark	Req.	P. O.	REMARKS
6	6"	high hub flanges 150# std.	0-21	A39158		2 extra
2	6" x 45°	Series 1-1/2R tube turns	"	A39159		
4	6"x8-3/4"x1/32"	corrugated copper gaskets	"	A39160		
32	3/4" x 4"	Class B stud bolts	"	A39161		
64	3/4"	carbon steel hex nuts	"	A39161		
1	6"x90 deg.	std. pipe bends 3'0" radius	"	A39162		3" tangents
2	4"	high hub flanges 150# std.	"	A39158		1 extra
2	4"	#47x valves	"	A39167		
4	4"x6-7/8"x1/32"	corrugated copper gaskets	"	A39160		
24	5/8"x3-3/4"	Class B stud bolts	"	A39161		
48	5/8"	carbon steel hex nuts	"	A39161		
1	6"x180 deg.	std. pipe bend 2'4" radius	"	A39162		
2	4"x90 deg.	series 1-1/2R tube turns	"	A39159		
1	4"	300# high hub flange 4-1/32" bore	"	A39158		
2	4"x7"x1/32"	corrugated copper gaskets	"	A39160		
10	3/4"x4-1/2"	Class B stud bolts	"	A39161		
40	lineal feet	6" std. steel pipe	"	A39164		
5	lineal feet	4" std. steel pipe	"	A39164		
1	1"	80X valve	"	A39167		
1	3/4"	80X valve	"	A39167		
1	1"	#2329 coupling	"	A39166		

FIG. 5—THE BILL OF MATERIAL

Particular attention is paid to the bill of material as shown in Fig. 5. The notations to be filled in above the listing space are considered to be of great importance because it is through them that all essential details concerning the particular bill of material on hand are noted.

The number of the general drawing from which the take-off is made, is, of course, essential. The bill of material number and spaces following permit identification of the total number of sheets to each take-off. In the "Job" space the building or unit is noted. There is a space for the work order number, and the job detail denotes the general identification of the unit to be constructed, such as "High Pressure Steam to Boiler Feed Pumps," etc. The particular line number is also noted in each case in the space denoted by "Mark." It should be understood that the materials for only one line are listed on each bill of material, and in no cases more than one line.

The "Date Listed" spaces bear the date of the take-off and the initials of the person performing it. After "Charge" the accounting code number for labor and material is listed; by it, the final and detailed cost of each unit, or each line, is determined.

Another item that calls for explanation is the space for "Revisions." As revisions in the drawings generally affect the materials, the bills of material are revised at the same time. This is important as it affects the total costs through returning material for credit. Strict attention in keeping bills up-to-date results in little surplus materials being left on the job.

Going further than the individual bills, there still remains the summarizing of similar materials on all the sheets. This summary is then issued to the purchasing department for procuring prices and purchase. The economy of this procedure over ill-timed take-offs is quite obvious.

The receiving department is given a copy of each bill of material. They then check off the material as it is received on the individual bills of material and notify the route clerk when all material for a line is received. Fore-

men and workmen are then informed that this line is ready to start. In this way starting a line and having to suspend work on it from lack of certain parts is prevented.

A practice that is much in evidence that is done away

with by this system is that of borrowing parts assigned for one line in order to complete another. This practice results in confusion and loss of time. This, and the custom of welders or mechanics to visit the stock room for parts consume a large part of the total man hours on the job; by proper handling of the bill of material system this loss is done away with.

To get all the detailed information and materials together, and in the hands of the workmen in the field, requires the undivided attention of the route clerk. He distributes all copies of the bills of material, job sketches, and details only when and where necessary. For instance, first copy of the bill of material goes to the receiving department for checking. When all material for a line is on hand this department notifies the route clerk who immediately turns over materials and sketches to either the welding shop and erection crew or merely the erection crew, who in turn start work, knowing that all the necessary material for that line is on hand.

In order that the field forces be constantly notified as to what lines to commence work on, a *Line List* is prepared every day by the route clerk. No line is posted until all material is on hand. The line list gives all the necessary information at a glance for both executive and field forces.

Realizing that things need straightening up occasionally even in the best regulated organizations, there is an individual provided by the organization whose only duty is to expedite the erection work. His ability to straighten out tangles adds considerably to the speed of the work, and he is the person to whom the foremen or anyone else apply for any needed acceleration of work or deliveries.

The welding foreman is responsible for all welding work done in both the shop and the field. Hiring and qualifying welders is one of his most important duties. Welders are required to pass definite qualification tests for the type of work which they will be required to do. All the work performed by the welding shop is done in accordance with the job sketches previously mentioned, and all pipe is fabricated to these details. This eliminates need for this work to be done in the field.

Any standard routine of cost keeping can be used with this system. Cost allocations, however, are more easily made than usual. By charging all labor to the unit or line on which the work is performed, the labor costs can be figured either on a percentage basis of the whole, as is usual, or they can be figured per lineal foot of line.

INTERESTING Equipment . . . Developments

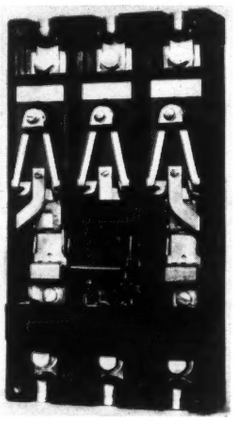
A Circuit Breaker

• A new breaker for circuit protection has been developed which opens a circuit without flash or undue noise. It is enclosed in a molded composition box so that no live parts are exposed. There are no parts that must be renewed, and it can be reclosed by means of a handle which protrudes through the cover.

The operating mechanism is arranged to provide quick "make" and quick "break." The contacts, which are trip free of the handle, are held in the closed position by a toggle composed of two sets of links, one of which is fulcrumed to the contact mechanism, and the other on a cradle beam pivoted on the frame at one end and latched to the trip mechanism on the other end. The trip mechanism consists of a bi-metal thermal unit calibrated to trip at 125% overload. On breakers of 50 amperes or more an additional trip of the magnetic type trips the breaker instantly on short circuits.

Upon being released by the trip mechanism, the cradle beam moves, permitting the toggle linkage to break and the contacts to open at high speed.

When the contacts open the arc is drawn through a series of small parallel plates one-sixteenth of an inch apart. Between the plates a radial magnetic field is created by a nearby coil. The arc creates another magnetic field which moves the arc into the



A Three-Pole, 225-Ampere Breaker with the Cover Removed

radial field. The plates absorb so many free ions that the arc is destroyed.

This circuit breaker is made by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

Compound Dehumidifies Air

● Lamisilite is the name of a new chemical compound announced last month which can be used in extracting moisture from the air. Its principal application is expected to be in connection with the smaller types of air conditioning equipment. Its name was derived from its laminated structure and siliceous nature.

In operation, the air to be conditioned is drawn through a water spray, where it is washed and cooled, and then passed over a bed of lamisilite. The lamisilite is dried out after it has absorbed moisture from the air by heating it with an automatically-controlled gas flame.

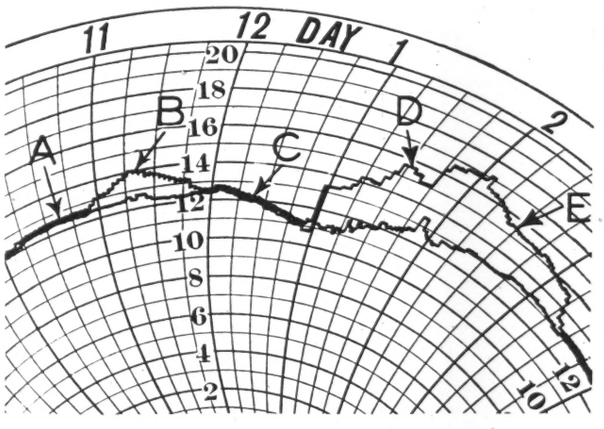
Announcement of this compound was made by Robert G. Guthrie, chief metallurgist of the Peoples Gas Light and Coke Company, Chicago, and Dr. Oscar J. Wilbor, research chemist.

Combustion Indicator-Recorder

● An instrument now being offered is an automatic flue gas analyzer which indicates and records the per cent of CO_2 and also gives a record of the per cent of combustibles such as $CO+H_2$ which may be present in the flue gases. The instrument is of all-metal construction.

This indicator-recorder works on the orsat principle, analyzing chemically and indicating and recording electrically. It is operated by the same caustic solution which makes the analysis; this solution requires renewal about once in every ten or twelve weeks. The illuminated dial and pointers are designed to be read at a distance of 30 ft. and the records are made on a 9-in., 24-hr. chart with open graduations to simplify careful study of the continuous performance curves.

The manufacturer is C. J. Tagliabue Mfg. Co., Park and Nostrand aves., Brooklyn, N. Y.



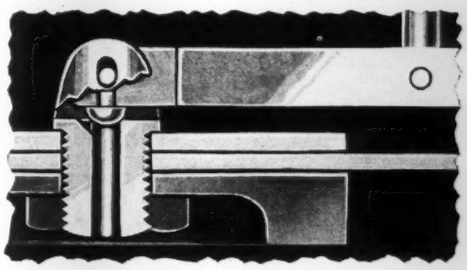
Section of Chart From Indicator-Recorder

When the black pointer covers the red one no combustibles are present in the gases and the recorder draws a single line as shown at *A*, where the CO_2 is 12½%, and at *C* where the CO_2 is 12%. Shortly before 11 o'clock the lines begin to separate.

The lower line is the per cent of CO_2 and the difference between the lower line and the upper line is the per cent of combustibles. Thus at *B* there is 1½% of combustible gases, at *D* there is 3¾% and at *E* there is 2½%.

Anti-Balancing Device for Traps

● A development in the construction of inverted bucket traps is the anti-balancing device illustrated here. It consists of a valve arrangement in the lever which replaces the air vent in the bucket. The valve has a small opening at all times to allow the air and other gases to escape from the bucket



Anti-Balancing Device for Inverted Bucket Traps

while the trap is filling. When the trap reaches the point of discharge, the larger valve is opened automatically, allowing a quantity of air to escape quickly from the bucket and sufficient water to enter the bucket. This overbalances the bucket and opens the main trap discharge valve.

This anti-balancing arrangement was developed by the Strong, Carlisle & Hammond Co., 1392 W. Third st., Cleveland, Ohio, and is applied to its present line of inverted bucket steam traps.

Protecting Galvanized Surfaces

● A corrosion-resisting material which was developed to extend the life of galvanized surfaces is a metal compound in liquid form, which acts as a primary coating to hold paint, enamel and lacquer tenaciously, permitting immediate finishing of new galvanized metal surfaces. It has been used to protect and preserve air ducts, roofing, siding, sheeting, etc., from the effects of gases, acid fumes, smoke, brine, etc.

In applying the compound, galvanized metal or zinc products can either be dipped in it or it can be put on with a brush. The treated surface is allowed to dry completely (ordinarily in from three to five hours) and immediately thereafter water is applied to the entire surface to complete the treatment. When applied with a brush, one gallon will cover approximately 1,000 sq. ft.; with dipping an average of 1,500 sq. ft. per gal. has been obtained.

It is produced by the Stibloy Products Company, Koppers Bldg., Pittsburgh, Pa.

Control for Hot Water Supply

● A device which automatically controls the temperature of hot water supply systems is a development which many engineers will find of interest. In hard water districts, its utility is readily apparent, as it may be set to hold the water at a temperature lower than that at which lime has tendency to form on the coils of the heater.

This temperature controller is most effective when